MICHIGAN DRY BEAN RESEARCH REPORT

2019

MSU Extension

Michigan BEAN COMMISSION

2019

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2019 Michigan Dry Bean Research

Scott Bales, MSU Dry Bean Specialist

In 2019 the Michigan Bean Commission was awarded two grants from the Michigan Department of Agriculture and Rural Development.

Project one titled: '***Integration of Sustainable Management Practices Essential for the Advancement of Michigan Dry Bean Production'*** was funded by specialty crop block grant program within the farm-bill. Objectives of this trial were to: (1) Development of bean cultivars and breeding lines with anthracnose resistance for disease control (site specific environmental/climate stressed conditions) within diverse production regions in Michigan. (2) Maximize yield through the optimization of harvest aid (desiccant) applications to reduce the prevalence of 'green stem' and to assure residue compliance at harvest. (3) Assessment of total nitrogen rates and time of application. Treatments will be designed to minimize total nitrogen applied during the pod development stage of growth (enhanced yield) thus reducing white mold infection. (4) Assessment of selected cover crops to improve soil conditions (sustainability and nutrient retention/bioavailability) and to enhance plant residue, as a means to establish a physical barrier that will reduce white mold disease spore transmission during bloom. (5) Assessment of suitable strategies for dry beans that undergo acute losses from white mold and root rot disease. Determine if a white mold prediction model will identify risk for white mold disease development and be a useful tool for Michigan dry bean growers. (6) Assessment of tile spacing and in-furrow and foliar fungicide applications on white mold and root rot control, under small and large plots. (7) Implementation of grower educational activates to communicate intervention strategies and economic options (current best management practices) used for the production of dry beans.

Project two titled: **'*Comprehensive Fertilizer Rate Recommendations for Michigan Dry Bean Growers: Strengthening Economic and Environmental Sustainability'*** was funded by the MDARD- fertilizer research program. The objectives of this project were to: (1) Assess nutrient requirements of new bean varieties for the major market classes grown in Michigan. (2) Provide grower guidelines for application of macro nutrients (N, P, K) based on physiological needs of the plant with particular needs for Phosphorous containment. (3) Provide optimum nitrogen requirements important to minimize plant canopy growth to assist with white mold proliferation, particularly in narrow row systems (4) Provide grower guidelines for application of micro nutrients (Zn and Mn). (5) Establish grower education of fertilizer application rates that include knowledge of soil fertility and crop rotations and carry over management. (6) Publish fertility manage requirements and management strategies for distribution to bean growers in Michigan.

Season Summary: The 2019 planting season was less than ideal for most crops in Michigan, dry beans included. Excessive levels of soil moisture from late May into July caused significant delays in dry bean planting across the state. However, the frequency of rainfall did eventually slow down through mid-summer. Some areas in the state became droughty during flowering, including Bay and Gratiot County dry bean variety trial locations. One benefit we did experience from being on the drier side through flowering was that white mold (*Sclerotinia sclerotiorum*) pressure was not high across the state in 2019. To the benefit of this research however, the Sanilac County variety trial location did have significant white mold pressure, allowing for the rating of white mold infection in the absence of fungicides. As dry bean harvest began the weather had a negative impact on field work once again. Harvest was done in small windows, followed by 7 to 10 day stretches of cold, wet weather. Overall, dry bean quality held up better than expected given the conditions. Of the 8 research locations included in this report the first was harvested on September 18th in Bay County. This trial had experienced water deficits and is one of our lowest yielding locations in 2019. The final location to be harvested was an irrigated white mold fungicide trial in Midland County on October 19th.

We would like to thank all cooperators that hosted trials in 2019. Without their assistance this research would not be possible.

2019 Michigan Dry Bean Variety Trials

Scott Bales, MSU Dry Bean Specialist

Table 1. Dry Bean variety trial locations, cooperators, planting date, harvest date, accumulated GDD from planting until harvest, total precipitation from planting until harvest, and white mold evaluation on a presence or absence bases.

County	Cooperator	Planting Date	Harvest Date	Total GDD*	Total Precipitation (inches)	White Mold (yes/no)
Bay	Schindler Farms	6/8	9/18	1756	10.0	NO
Gratiot	Steve Hoard Farms	6/8	10/9	2168	18.8	NO
Sanilac	Dave's Dirt	6/9	9/24	1918	9.5	YES
Tuscola	Bednarski Farms	6/9	9/26	2159	11.5	NO
Montcalm	Rader Farms	6/12	10/10	1956	16.1 + Irrigation	YES
Huron	J.A.D.E. Farms	6/22	10/7	1806	9.1	NO

*Weather data retrieved from the nearest Michigan Automated Weather Network (MAWN) and the Enviro-weather Program station nearest to the trial. All weather data is from the day of planting to harvest. Growing degree days were calculated using the following equation: $(\frac{\max+\min}{2}) - 50$

Methods: For these six dry bean variety trials beans are seeded in four row plots (20" rows) that measure 6.6' wide by 20' long. Each entry is replicated **four** times within the trial. All trials receive 60 lb./A of nitrogen broadcast. Industry standard PPI or PRE herbicides are applied by the cooperator. POST weed control consist of a mixture of Rapor (4 fl oz) + Basagran (16 fl oz) + Reflex (8 fl oz) + Asana (4 fl oz) + COC (1% v/v) + AMS (2.5 lb/A). In 2019 Montcalm and Bay County were not sprayed POST do to exceptional weed control by PPI applications. White mold fungicides are not applied to any variety trials, this allows the evaluation of a varieties natural tolerance or avoidance to white mold when the disease is present. Yield data is obtained by direct harvest for small and medium seeded beans. Large seeded beans are pulled by hand and then mechanically thrashed to prevent harvest loss. Samples are weighed and moisture is taken at harvest, data is then adjusted to 18% moisture and analyzed at $\alpha \leq 0.05$. Questions regarding the 2019 variety trials, or suggestions for 2020 should be directed to Scott Bales: (989)-262-8550; Balessco@msu.edu**.**

Table 2. Navy bean varieties, average maturity, yields at four county locations in 2019, average yields by variety for Bay, Huron, Sanilac, and Tuscola County in 2019 (1-year AVG.), 2018-2019 (2-year AVG.), 2017-2019 (3-year AVG.), white mold rating (1-5) and lodging rating (1-5).

VARIETY	DAYS	BAY	HURON	SANILAC	TUSCOLA	1-year AVG.	2-year AVG.	3-year AVG.	WM Rating[a]	Lodging[b]
HMS MEDALIST	98-106	1834*	2934	3619*	2682	2767	2714	2599	2.1	2.5
MERLIN	98-106	1766*	3231	2682	2150	2457	2816*	2623	2.0	2.0
APEX	95-104	1769*	2911	3448*	2974	2776*	2872*	-	1.8	2.0
BLIZZARD	94-99	1476*	3176	3064	2859	2644	2708	2565	2.3	1.5
INDI	89-96	1442	3182	2547	2476	2412	2529	-	2.0	1.5
VIGILANT	91-96	2024**	3199	2437	2817	2619	-	-	2.4	2.0
REXETER	93-106	1544*	3923**	2371	3148	2747	2645	2540	2.8	2.5
NAUTICA	94-104	1919*	3131	2402	2854	2577	2432	2497	1.8	2.0
MIST	93-102	1748*	3258	2969	2660	2659	2645	2499	1.5	2.5
ARGOSY	92-100	1896*	3374	3173*	2973	2854*	2846*	2841*	2.2	2.5
EX 1701	92-100	1154	2708	2548	2139	2137	2462	-	2.6	2.5
EX 1702	94-102	1470*	2648	2652	2522	2323	2639	-	2.3	2.5
EX 1708	95-103	855	3041	1913	1603	1853	-	-	-	-
EX 1711	93-100	1301	2881	2184	2461	2207	-	-	-	-
VALIANT	92-100	1332	3151	3208*	2430	2530	-	-	-	-
PROVITA 12039	92-99	1828*	3067	3651**	3410*	2989	3032**	2912**	2.6	2.5
HMS BOUNTY	93-104	1441	3164	2655	2902	2541	2981*	2782*	1.3	1.5
PROVITA 12062	94-101	1608*	3773*	3109*	3236*	2932	2912*	2862*	2.8	2.5
PROVITA 12063	95-102	1448	3564*	2861	3569*	2861*	2960*	2867*	2.2	1.5
PROVITA 12064	96-104	1452*	2915	-	-	-	2496	2584	1.6	2.0
ARMADA	96-102	1541*	3530*	3575*	2821	2867*	2956*	2823*	2.0	2.0
PROVITA 14068	96-100	1968*	2976	2432	3087	2616	2700	2774*	3.0	2.0
PROVITA 14080	95-102	1630*	3330	3008	2853	2705	-	-	-	-
PROVITA 14084	97-104	1563*	2791	2789	3082	2556	2707	2738	3.1	2.0
PROVITA 15094	93-102	1579*	3860*	3537*	2948	2981*	2956*	-	2.1	2.5
PROVITA 15095	96-104	1518*	3312	3490*	3892**	3053**	2996*	-	3.2	3.0
SV1893GH	97-106	-	2736	1796	-	-	2433	-	2.0	2.5
MSU N17506	95-98	1622	3290	2602	2635	2537	2363	-	3.5	1.5
MSU N18102	96-99	1397	2866	2765	2259	2322	-	-	-	-
MSU N18109	96-98	1649*	3159	2722	3612*	2786*	-	-	-	-
EX 1801	97-98	-	3227	-	2562	-	-	-	-	-
EX 1802	94-95	-	3168	-	2162	-	-	-	-	-
EX 1803	96-98	-	2966	-	1557	-	-	-	-	-
EX 1804	96-97	-	3304	-	2675	-	-	-	-	-
MEAN:		1578	3169	2835	2750	2618	2731	2701	2.3	2.1
LSD$_{(0.05)}$:		573	497	572	718	277	218	170		
CV:		30%	13%	16%	22%	25%	19%	18%		

**Highest yielding variety within column

*Yield not statistically different than the highest yielding variety within column ($\alpha \leq 0.05$)

[a] White mold ratings: 1= less than 10% infection, 5= greater than 60% infection

[b] Lodging Scores: 1= very erect, 5= pods and stems on the ground

Table 3. Black bean varieties, average maturity, yields at four county locations in 2019, average yields by variety for Bay, Huron, Sanilac, and Tuscola County in 2019 (1-year AVG.), 2018-2019 (2-year AVG.), 2017-2019 (3-year AVG.), white mold rating (1-5) and lodging rating (1-5).

VARIETY	DAYS	BAY	HURON	SANILAC	TUSCOLA	1-year AVG.	2-year AVG.	3-year AVG.	WM Rating[a]	Lodging[b]
ZORRO	93-102	1470	2416	3138*	2816	2460	2540	2426	2.6	2.0
ZENITH	93-104	1539	2625*	3282*	2506	2488	2673	2504	2.4	2.0
LORETO	94-104	1123	2721*	2977	3055	2469	2694	2643	3.3	2.0
BLACK CAT	92-100	1595	2535	2750	2790	2418	2618	2552	3.3	2.0
BLACK BEAR	97-104	1466	2657*	3227	3612	2741	2672	2539	3.0	2.0
BLACK TAILS	94-102	1259	2609	2788	3432	2522	2740	2639	3.3	2.5
BLACK BEARD	96-100	1909*	3193*	3782**	3195	3020*	3190*	3040	2.4	2.0
SPECTRE	96-104	1625	2719*	3514*	3190	2762	3122*	3009	1.9	2.5
BL 13505	92-100	1903*	2973*	2793	3047	2679	2743	2652	4.3	2.5
BL 14500	97-106	1979*	3060*	3563*	3563	3041*	3337**	3224**	2.6	2.0
BL 15610	95-106	1546	2524	3739*	3284	2773	2749	-	2.5	2.0
BL 15619	93-104	2069*	2588	2540	2876	2518	2558	-	3.6	2.0
MSU B15447	97-100	1800*	2902*	3508*	3737*	2987*	-	-	3.0	2.0
MSU B16504	95-100	2229**	2845*	3308*	2768	2788	3109*	3074	2.8	2.0
MSU B17922	96-100	1802*	3102*	2963	3568	2859	-	-	2.5	2.0
MSU B18201	96-102	2136*	3282**	3329*	4268**	3254**	-	-	2.6	2.0
MSU B18204	95-100	1609	3000*	2888	2662	2540	-	-	2.6	2.0
MSU B18504	96-100	1675	3099*	3343*	3700*	2954	3068	-	2.6	2.0
GTS B13SR1-1	94-100	1915*	2854*	2193	3152	2529	-	-	3.5	2.0
ADM B2007325	97-99	-	-	2837	3816*	-	-	-	3.8	2.5
ADM B3036368	97-98	-	-	2554	2516	-	-	-	4.3	2.5
ADM B3036381	96-97	-	-	2546	2935	-	-	-	4.5	3.0
ACE	97-98	-	-	2858	3194	-	-	-	3.8	3.0
ECLIPSE	92-96	-	-	2512	3295	-	-	-	4.3	3.0
MEAN:		1718	2827	3039	3207	2726	2779	2775	3.1	2.2
$LSD_{(0.05)}$:		439	662	679	568	298	236	160		
CV:		21%	19%	19%	15%	23%	20%	17%		

**Highest yielding variety within column

*Yield not statistically different than the highest yielding variety within column ($\alpha \leq 0.05$)

[a] White mold ratings: 1= less than 10% infection, 5= greater than 60% infection

[b] Lodging Scores: 1= very erect, 5= pods and stems on the ground

Table 4. Small Red and Pink Bean varieties, average maturity, yields at four county locations in 2019, average yields by variety for Bay, Huron, Sanilac, and Tuscola County in 2019 (1-year AVG.), 2018-2019 (2-year AVG.), 2017-2019 (3-year AVG.), white mold rating (1-5) and lodging rating (1-5).

VARIETY	DAYS	BAY	HURON	SANILAC	TUSCOLA	1-year AVG.	2-year AVG.	3-year AVG.	WM Rating[a]	Lodging[b]
VIPER	93-104	1882*	2610*	3608*	3885*	2996**	3162*	3175**	3.8	2.5
RUBY	92-104	1472*	2644*	2970	2855	2485	2710	2725	3.8	4.0
CALDERA	97-108	1578*	2299*	3641**	4237**	2939*	3020*	3084*	3.0	2.5
CAYENNE	91-100	1859*	2777*	2942	3328	2727*	3097*	3032*	2.0	2.5
MSU R17603	96-104	1594*	2880**	3560*	2990	2756*	3207**	-	3.0	2.5
MSU R17604	97-105	1378	2450*	3130*	3302	2565	-	-	2.4	3.5
MSU R17605	95-104	1537*	2453*	3043*	3422	2614	-	-	2.5	3.0
PROVITA 16686	91-101	1801*	1702	2503	3955*	2490	-	-	3.9	3.0
PROVITA 17835	93-102	1865**	2453*	2919	2704	2485	-	-	2.8	3.0
PROVITA 17837	90-103	1335	2682*	3167*	3177	2590	-	-	3.0	2.5
PROVITA 17839	93-102	1294	2461*	2982	2528	2316	-	-	3.4	2.5
ROSETTA PINK	93-105	1542*	2561*	2075	2021	2050	2561	2528	1.9	2.0
S18904	95-104	1705*	2256	3067*	2757	2446	-	-	2.1	2.5
MEAN:		1603	2479	3047	3166	2574	2960	2909	2.9	2.8
$LSD_{(0.05)}$:		450	607	646	536	293	220	172		
CV:		23%	21%	17%	14%	25%	18%	18%		

**Highest yielding variety within column

*Yield not statistically different than the highest yielding variety within column ($\alpha \leq 0.05$)

[a] White mold ratings: 1= less than 10% infection, 5= greater than 60% infection

[b] Lodging Scores: 1= very erect, 5= pods and stems on the ground

Table 5. Pinto bean varieties, average maturity, yields at four county locations in 2019, average yields by variety for Bay, Gratiot, Huron, Montcalm, and Sanilac County in 2019 (1-year AVG.), white mold rating (1-5) and lodging rating (1-5).

VARIETY	DAYS	BAY	GRATIOT	HURON	MONTCALM	SANILAC	1-year AVG.	WM Rating[a]	Lodging[b]
LA PAZ	90-95	1922*	2127	2271*	2291	2934**	2309	4.6	3.0
MSU P16901	95-102	2188*	2671**	2368*	2639	2322*	2438*	4.4	3.5
MSU P17510	93-104	2223**	2250*	2618**	3384**	2792*	2653**	3.1	2.0
MSU P18602	96-102	1345	1862	2316*	1394	2661*	1916	4.3	3.0
WINDBREAKER	87	-	-	2071	-	-	-	-	-
SV6139GR	89	-	-	2496*	-	-	-	-	-
SV6533GR	88	-	-	2422*	-	-	-	-	-
MEAN:		1920	2228	2366	2427	2677	2329	4.1	2.9
LSD$_{(0.05)}$:		424	483	417	304	1500	318		
CV:		17%	16%	14%	cv-5%	43%	26%		

**Highest yielding variety within column
*Yield not statistically different than the highest yielding variety within column ($\alpha \leq 0.05$)
[a] White mold ratings: 1= less than 10% infection, 5= greater than 60% infection
[b] Lodging Scores: 1= very erect, 5= pods and stems on the ground

Table 6. Great Northern bean varieties, average maturity, yields at four county locations in 2019, average yields by variety for Bay, Gratiot, Montcalm, and Tuscola County in 2019 (1-year AVG.), white mold rating (1-5) and lodging rating (1-5).

VARIETY	DAYS	BAY	GRATIOT	MONTCALM	TUSCOLA	1-year AVG.	WM Rating[a]	Lodging[b]
POWDERHORN	90-92	883	1295	3097*	1229	1626	5.0	2.0
MSU G16351	98-105	2066**	2627*	3142*	3204*	2760*	3.0	2.0
MSU G17410	94-102	2001*	2845**	3818**	3416**	3020**	3.0	2.0
ARIES GN	90-92	1246	1588	3160*	1748	1936	5.0	2.0
GN 13172	97-103	1525*	2331	2740	3213*	2452	4.0	3.0
MEAN:		1544	2137	3191	2562	2359	4.0	2.2
LSD$_{(0.05)}$:		625	421	849	742	365		
CV:		37%	15%	23%	24%	29%		

**Highest yielding variety within column
*Yield not statistically different than the highest yielding variety within column ($\alpha \leq 0.05$)
[a] White mold ratings: 1= less than 10% infection, 5= greater than 60% infection
[b] Lodging Scores: 1= very erect, 5= pods and stems on the ground

Table 7. Cranberry bean varieties, average days maturity, yield at Gratiot (Dry Land) and Montcalm (Irrigated) county locations in 2019, average yields for 2018-2019 (2-year AVG.), 2017-2019 (3-year AVG.) for Dry Land and Irrigated locations, and white mold rating (1-5).

VARIETY	DAYS	GRATIOT	MONTCALM	Irrigated 2-year AVG.	Irrigated 3-year AVG.	Dry Land 2-year AVG.	Dry Land 3-year AVG.	WM Rating[a]
ETNA	88-91	707	4109**	3512*	3335	1803	1941	1.0
*CHIANTI****	96-99	731	3780*	3607*	3365	1918	2411	2.0
*BELLAGIO****	102-104	1585*	3405	3568*	3336	2263	2441	3.0
SV3709GC	88-90	1382*	3970*	-	-	-	-	1.0
VERO	88-91	-	3468	3276	3368	-	-	2.0
GTS Red Cran R172	87-90	1719*	2721	-	-	-	-	1.0
CR 151085	95-102	1773*	3601*	3909**	3783**	2460*	2674*	3.0
CR 151093	95-102	1853**	3228	3285	3149	2704**	2773**	2.0
CR 151106	95-96	562	3977*	3474*	3226	1739	2030	1.0
CR 16760	90-93	1623*	3566	3345	-	2506*	-	2.0
CR 16761	90-92	1141	3568	3561*	-	2141	-	2.0
CR 16764	88-90	1351	3143	2703	-	2235	-	3.0
CR 16775	96-98	1153	3483	-	-	-	-	1.0
MEAN:		1298	3540	3424	3366	2197	2378	1.8
$LSD_{(0.05)}$:		492	526	447	396	290	278	
CV:		32%	12%	16%	17%	16%	17%	

***Vine type

**Highest yielding variety within column

*Yield not statistically different than the highest yielding variety within column ($\alpha \leq 0.05$)

[a]White mold ratings: 1= less than 10% infection, 5= greater than 60% infection

Table 8. Light Red Kidney bean varieties, average days maturity, yield at Gratiot (Dry Land) and Montcalm (Irrigated) county locations in 2019, average yields for 2018-2019 (2-year AVG.), 2017-2019 (3-year AVG.) for Dry Land and Irrigated locations, and white mold rating (1-5).

VARIETY	DAYS	GRATIOT	MONTCALM	Irrigated 2-year AVG.	Irrigated 3-year AVG.	Dry Land 2-year AVG.	Dry Land 3-year AVG.	WM Rating[a]
CALIF ELRK	88-92	1493	3630*	3162	3288*	1808	2049	2.0
CLOUSEAU	92-95	1380	3763**	3581*	3696*	1943	2160	2.0
INFERNO	108-109	2521	2447	3541*	3546*	2853**	2936**	2.0
BIG RED	88-96	1937	3136*	2999	3350*	2018	2211	2.0
RONNIES RED	102-106	2607*	2824	3643*	3762**	2669*	2855*	3.0
RED DAWN	86-91	1491	3654*	3493*	3557*	1854	2102	1.0
LRK 06269	104-105	2202	2982*	3675*	3491*	2209	2321	4.0
LRK 15907	108-109	2577*	2421	2952	3106	2638*	2802*	3.0
LRK 15926	106-109	2142	2426	3037	3016	2312	2521*	4.0
COHO	102-104	2435*	2699	3432*	3182	2443	2291	3.0
MSU K17703	102-103	1922	3372*	3978**	-	2350	-	2.0
MSU K18501	107-108	2642**	2767	-	-	-	-	2.0
ADM L1032326	108-109	-	2594	-	-	-	-	3.0
ADM L4063262	109-110	-	2851	-	-	-	-	3.0
MEAN:		2112	2969	3408	3400	2282	2425	2.6
$LSD_{(0.05)}$:		390	805	635	478	322	273	
CV:		15%	22%	22%	21%	17%	17%	

**Highest yielding variety within column

*Yield not statistically different than the highest yielding variety within column ($\alpha \leq 0.05$)

[a]White mold ratings: 1= less than 10% infection, 5= greater than 60% infection

Table 9. Dark Red Kidney bean varieties, average days maturity, yield at Gratiot (Dry Land) and Montcalm (Irrigated) county locations in 2019 and average yields for 2018-2019 (2-year AVG.), 2017-2019 (3-year AVG.) for Dry Land and Irrigated locations, and white mold rating (1-5).

VARIETY	DAYS	GRATIOT	MONTCALM	Irrigated 2-year AVG.	Irrigated 3-year AVG.	Dry Land 2-year AVG.	Dry Land 3-year AVG.	WM Rating[a]
RED HAWK	100-102	1877	3708*	3745*	3558*	2123	-	3.0
MONTCALM	102-104	1823	3433*	3685*	3504*	1986	-	2.0
RED ROVER	94-95	1761	3567*	3468	3343*	2023	-	2.0
DYNASTY	106-107	2017	3506*	3923**	3697**	2397*	-	2.0
RED CEDAR	98-99	2099	2684	3140	3018	2263	2673	2.0
MSU K16131	100-102	1928	2637	3219	-	2133	-	2.0
MSU K16136	100-101	1950	3277*	3575*	3681*	2325	-	2.0
CHAPARRAL	101-104	1556	2638	3504	3197	1922	-	3.0
EPIC	103-106	2044	3199*	3415	3360*	2289	3272*	2.0
SPIRE	104-107	2083	2302	3721*	3309	2295	3407**	2.0
RAMPART	92-100	1673	2892	3429	-	2088	-	1.0
DRK 15978	99-104	2652**	2181	3920*	3233	2629**	-	3.0
DRK 15981	102-105	1819	2099	-	-	-	-	2.0
DRK 151011	96-100	2029	2496	3483	3278	2380	-	1.0
ADM D1034333	101	-	3883**	-	-	-	-	1.0
ADM D5004231	102	-	3799*	-	-	-	-	2.0
MEAN:		1951	3019	3556	3380	2219	3117	2.0
LSD$_{(0.05)}$:		441	707	365	383	277	394	
CV:		19%	19%	12%	17%	15%	18%	

**Highest yielding variety within column

*Yield not statistically different than the highest yielding variety within column ($\alpha \leq 0.05$)

[a]White mold ratings: 1= less than 10% infection, 5= greater than 60% infection

Table 10. White Kidney bean varieties, average days maturity, yield at Gratiot (Dry Land) and Montcalm (Irrigated) county locations in 2019, average yields for 2018-2019 (2-year AVG.), 2017-2019 (3-year AVG.) for Dry Land and Irrigated locations, and white mold rating (1-5).

VARIETY	DAYS	GRATIOT	MONTCALM	Irrigated 2-year AVG.	Irrigated 3-year AVG.	Dry Land 2-year AVG.	Dry Land 3-year AVG.	WM Rating [a]
BELUGA	105-106	2392**	2659	3083	2983	2365*	-	2.0
SNOWDON	90-92	1418	4243*	3611*	3316	2081*	-	1.0
MSU K16924	94-95	1899*	4317*	4034**	3846**	2234*	2348	1.0
MSU K17804	107-108	2237*	3261	3615*		2468**	-	2.0
MSU K18912	92-94	1549	4451**	-		-	-	2.0
YETI	107-109	1477	3849	3820*	3608*	2261*	-	1.0
MEAN:		1829	3797	3632	3438	2282	-	1.5
LSD$_{(0.05)}$:		529	374	456	361	389	-	
CV:		23%	8%	15%	15%	20%	-	

**Highest yielding variety within column

*Yield not statistically different than the highest yielding variety within column ($\alpha \leq 0.05$)

[a]White mold ratings: 1= less than 10% infection, 5= greater than 60% infection

Table 11. Yellow bean varieties, average days maturity, yields at Gratiot (Dry Land) and Montcalm (Irrigated) county locations in 2019, average yields for 2018-2019 (2-year AVG.), 2017-2019 (3-year AVG.) for Dry Land and Irrigated locations, and white mold rating (1-5).

VARIETY	DAYS	GRATIOT	MONTCALM	Irrigated 2-year AVG.	Dry Land 2-year AVG.	WM Rating[a]
MSU Y16503	107-108	1546	3519*	3154	2177	1.0
MSU Y16507	96-99	1915*	3914**	-	-	2.0
PROVITA 13655	104-106	1917**	3287	-	-	2.0
SVS 0863	105-106	1840*	3387	-	-	4.0
MEAN:		1805	3527	-	-	2.3
LSD$_{(0.05)}$:		324	520	-	-	
CV:		14%	15%	-	-	

**Highest yielding variety within column

*Yield not statistically different than the highest yielding variety within column ($\alpha \leq 0.05$)

[a]White mold ratings: 1= less than 10% infection, 5= greater than 60% infection.

Table 12. Dry bean variety sourcing information, sorted alphabetical by variety name within source and market class.

Archer Daniels Midland (ADM):

ACE (ADM B8006282)	BLACK
ADM B2007325	BLACK
ADM B3036368	BLACK
ADM B3036381	BLACK
ADM L1032326	LIGHT RED KIDNEY
ADM L4063262	LIGHT RED KIDNEY
GN 13172	GREAT NORTHERN
VERO	CRANBERRY
INDI	NAVY

Canada-Hensall District Coop:

ARGOSY	NAVY
MIST	NAVY
NAUTICA	NAVY
REXETER	NAVY
INFERNO	LIGHT RED KIDNEY
DYNASTY	DARK RED KIDNEY
YETI	WHITE KIDNEY

Cooperative Elevator Company:

HMS MEDALIST (ADM)	NAVY
MERLIN (ADM)	NAVY
BLACK CAT (ProVita)	BLACK
LORETO (ProVita)	BLACK

Gen-Tec Seeds LTD:

GTS B13SR1-1	BLACK
GTS RED CRAN R172	CRANBERRY

Michigan State University:

MSU N17506	NAVY
MSU N18102	NAVY
MSU N18109	NAVY
CAYENNE	S.RED/PINK
MSU R17603	S.RED/PINK
MSU R17604	S.RED/PINK
MSU R17605	S.RED/PINK
ROSETTA PINK	S.RED/PINK
S18904	S.RED/PINK
MSU B15447	BLACK
MSU B16504	BLACK
MSU B17922	BLACK
MSU B18201	BLACK

ProVita:

ARMADA (PROVITA 13068)	NAVY
BLIZZARD	NAVY
BOUNTY (PROVITA 12047)	NAVY
PROVITA 12039	NAVY
PROVITA 12062	NAVY
PROVITA 12063	NAVY
PROVITA 12064	NAVY
PROVITA 14068	NAVY
PROVITA 14080	NAVY
PROVITA 14084	NAVY
PROVITA 15094	NAVY
PROVITA 15095	NAVY
VALIANT (PROVITA 08077)	NAVY
VIGILANT	NAVY
CALDERA (SR11511)	S.RED/PINK
PROVITA 16686	S.RED/PINK
PROVITA 17835	S.RED/PINK
PROVITA 17837	S.RED/PINK
PROVITA 17839	S.RED/PINK
RUBY	S.RED/PINK
VIPER	S.RED/PINK
BL 13505	BLACK
BL 14500	BLACK
BL 15610	BLACK
BL 15619	BLACK
BLACK BEAR	BLACK
BLACK BEARD (BL 14506)	BLACK
BLACK TAILS	BLACK
SPECTRE (BL 14497)	BLACK
LA PAZ	PINTO
ARIES GN	GREAT NORTHERN
CR 151085	CRANBERRY
CR 151093	CRANBERRY
CR 151106	CRANBERRY
CR 16760	CRANBERRY
CR 16761	CRANBERRY
CR 16764	CRANBERRY
CR 16775	CRANBERRY
BIG RED	LIGHT RED KIDNEY

Michigan State University: Cont'd

MSU B18204	BLACK
MSU B18504	BLACK
ZENITH	BLACK
ZORRO	BLACK
MSU P16901	PINTO
MSU P17510	PINTO
MSU P18602	PINTO
WINDBREAKER	PINTO
MSU G16351	GREAT NORTHERN
MSU G17410	GREAT NORTHERN
POWDERHORN	GREAT NORTHERN
BELLAGIO	CRANBERRY
COHO (MSU15601)	LIGHT RED KIDNEY
MSU K17703	LIGHT RED KIDNEY
MSU K18501	LIGHT RED KIDNEY
MONTCALM	DARK RED KIDNEY
MSU K16131	DARK RED KIDNEY
MSU K16136	DARK RED KIDNEY
RED CEDAR	DARK RED KIDNEY
RED HAWK	DARK RED KIDNEY
BELUGA	WHITE KIDNEY
MSU K16924	WHITE KIDNEY
MSU K17804	WHITE KIDNEY
MSU K18912	WHITE KIDNEY
SNOWDON	WHITE KIDNEY
MSU Y16503	YELLOW
MSU Y16507	YELLOW
FUJI	TEBO
SAMURAI	TEBO

North Dakota State University:

ECLIPSE	BLACK

ProVita: Cont'd

LRK 06269	LIGHT RED KIDNEY
LRK 15907	LIGHT RED KIDNEY
LRK 15926	LIGHT RED KIDNEY
RED DAWN (LRK 09363)	LIGHT RED KIDNEY
RONNIES RED (LRK 09360)	LIGHT RED KIDNEY
ADM D1034333	DARK RED KIDNEY
ADM D5004231	DARK RED KIDNEY
CHAPARRAL	DARK RED KIDNEY
DRK 151011	DARK RED KIDNEY
DRK 15978	DARK RED KIDNEY
DRK 15981	DARK RED KIDNEY
EPIC (DRK 09430)	DARK RED KIDNEY
RAMPART (DRK 09434)	DARK RED KIDNEY
SPIRE (DRK 09431)	DARK RED KIDNEY
PROVITA 13655	YELLOW

Seminis Seeds:

SV1893GH	NAVY
SV6139GR	PINTO
SV6533GR	PINTO
CHIANTI	CRANBERRY
ETNA	CRANBERRY
SV3709GC	CRANBERRY
CLOUSEAU	LIGHT RED KIDNEY
RED ROVER	DARK RED KIDNEY
SVS 0863	YELLOW

Treasure Valley Seeds:

APEX	NAVY
EX 1701	NAVY
EX 1702	NAVY
EX 1708	NAVY
EX 1711	NAVY
EX 1801	NAVY
EX 1802	NAVY
EX 1803	NAVY
EX 1804	NAVY

University of California:

CALIF ELRK	LIGHT RED KIDNEY

2019 Montcalm County White Mold Fungicide Trial

Scott Bales, MSU Dry Bean Specialist

Location: Entrican, MI (Irrigated)	**Treated Plot Size:** 6.6' x 20'
Planting Date: June 7	**GPA:** 22
Replicated: 4 times	**PSI:** 60
Variety: Black Bear	**Nozzle:** TP8002VS
Population: 120,000 seeds/A	**Application A (R1):** July 29
Row width: 20-inch	**Application B:** August 12

Table 1. White mold fungicide treatments, application timing, disease ratings (1-9), percent infection, and dry bean yield.

Treatments	Application Timing	Disease Rating*	White Mold (% Infection)	Yield**
Propulse (10.3 fl oz) fb. Endura (8 oz)	A+B	2.25 a-c	16 ab	4020 a
Omega (8 fl oz) fb. Endura (8 oz)	A+B	2.25 a-c	10 ab	3527 ab
Propulse (10.3 fl oz)	B	2.75 a-d	13 ab	3378 a-c
Omega (8 fl oz)	AB	2.5 a-c	15 ab	3280 b-d
Endura (8 oz)	AB	2.25 a-c	12 ab	3233 b-e
Endura (8 oz)	B	2 ab	9 ab	3102 bc
Propulse (fl 10.3 oz)	AB	2.5 a-c	10 ab	2963 b-f
Endura (8 oz)	A	3.25 b-f	12 ab	2765 c-f
Proline (5.7 fl oz)	AB	3.25 b-f	39 c-e	2754 b-f
Propulse (10.3 fl oz)	A	3 a-d	20 a-d	2562 d-f
Omega (8 fl oz)	A	3.5 b-f	45 d-f	2551 ef
Zolera (5 fl oz)	AB	5.25 g	58 ef	2496 f
Double Nickel (64 fl oz)	AB	4.25 d-g	50 ef	2420 f
Double Nickel (32 fl oz)	AB	4.5 e-g	60 f	2368 f
Untreated	-	4.75 fg	61 f	2241 f

*Means within the same column with different letters are not significantly different from each other ($\alpha \leq 0.05$).
**Yield is in pounds per acres obtained by direct harvest and adjusted to 18% moisture.

Summary: This study was conducted to investigate the effects of multiple fungicides and application timings on white mold infection and dry bean yield. Table 1 is sorted in descending order by yield, with treatments of Propulse, Endura, and Omega in combination grouping towards the top. This result is not unexpected as these products have performed very well on white mold in other trials and past years. When analyzing the effects of application timing this study indicates that later applications (B) may have greater efficacy on white mold than early applications (A). The area of application timing will be the subject of future research trials in 2020.

Midland County White Mold Fungicide Trials

Scott Bales, MSU Dry Bean Specialist

Location: Midland County (Irrigated)	**Treated Plot Size:** 6.6’ x 20’
Planting Date: June 7	**GPA:** 22
Replicated: 4 times	**PSI:** 60
Variety: Black Bear	**Nozzle:** TP8002VS
Population: 120,000 seeds/A	**Application A (R1):** July 24
Row width: 20-inch	**Application B:** August 5

Table 1. White mold fungicide treatments, application timing, disease ratings (1-9), percent infection, and dry bean yield.

Treatments	Application Timing	Disease Rating	White Mold (% Infection)	Yield
Propulse (10.3 fl oz)	AB	2 a	13 a	3958 a
Omega (8 fl oz)	AB	3 b	27 b	3818 a
Endura (8 oz)	AB	2 a	8 a	3760 a
Proline (5.7 fl oz)	AB	4 c	31 b	3432 ab
Untreated	-	5 d	59 c	3116 b

Table 2. White mold fungicide treatments, application timing, disease ratings (1-9), percent infection, and dry bean yield.

Treatments	Application Timing	Disease Rating	White Mold (% Infection)	Yield
Endura (8 oz)	AB	3 ab	80 b	4098 a
Omega (8 fl oz)	AB	3 ab	59 a	4000 a
Propulse (10.3 fl oz)	AB	2 a	79 b	3636 a
Contans (2 lb)	PRE	6 c	86 bc	2898 b
Untreated	-	4 b	95 c	2697 b

*Means within the same column with different letters are not significantly different from each other ($\alpha \leq 0.05$).
**Yield is in pounds per acres obtained by direct harvest and adjusted to 18% moisture.

Summary: Two fungicide trials were established in Midland County in 2019. These studies were conducted to investigate the effects of multiple fungicides and application timings on white mold infection and dry bean yield. Both trials were irrigated at a rate of 0.5” per week through flowering to encourage white mold infection. In both trials the applications of Endura, Omega, and Propulse at R1 (A) and then again (B) 12 d later provided the highest dry bean yields. In the second study (Table 2) Contans, a biological, was applied to the soil and incorporated the day of dry bean planting. Label recommendations for Contans do encourage the repeated use of this product in a rotation as its effectiveness may increase with continued use reducing soil inoculum. However, that was not the focus of this trial. Neither white mold infection, nor yield were effected by Contans in 2019 when compared to the untreated.

2019 Navy Bean Response to Nitrogen Strip Trial

Scott Bales, MSU Dry Bean Specialist

Location: Unionville, MI	**Treated Plot Size:** 6.5 Acres
Planting Date: July 1	**N Source:** UAN (28-0-0)
Replicated: 1 time	**Weed Control:** July 17
Variety: Blizzard	**Fungicide App. A:** August 12
Population: 120,000 seeds/A	**Fungicide App. B :**August 21
Row width: 22-inch	**Field Average:** 2898 lb./A

Table 1. Fertilizer treatments, application timing, white mold percent infection, and dry bean yield.

Treatments (lb. N/acre)	Application Timing (2x2 at planting)	White Mold (% Infection)	Yield**
20	PRE	-	3091
40	PRE	-	3202
60	PRE	-	3115
80	PRE	-	2961

**Yield is in pounds per acres obtained by direct harvest and adjusted to 18% moisture.

Summary: This trial was established in 2019 to investigate navy beans response to multiple rates of nitrogen. Due to limiting factors only one replication of this study was able to be planted and harvested. However, due to very uniform soil and field conditions we believe the data still provides valuable insight into dry beans response to nitrogen. In this trial dry beans did not show a large response to nitrogen. Future nitrogen trials will more extensively review previous crop management as well as base line nitrate and ammonium concentrations in the soil. These insights may provide valuable information for dry bean management decisions. When analyzing dry beans response to nitrogen we are also interested in the potential interaction with white mold. Past research has indicated that white mold disease can be more severe with increased rates of nitrogen. In 2019 environmental conditions were not favorable in this location for white mold infection. Thus not allowing the evaluation of white mold disease under these different rates of nitrogen fertilizer. The interaction between nitrogen fertility and white mold will be the focus of future research projects.

2019 Black Bean Response to Nitrogen, Sulfur, and Plant Populations

Scott Bales, MSU Dry Bean Specialist

In 2019 three separate dry bean trials were planted at the Answer Plot location near Gagetown, MI. Trials included a Nitrogen Rate Response, Sulfur Rate Response, and Plant Population Trials. Trials were established as a cooperative effort between MSU Dry Bean Specialist Scott Bales and Winfield United Agronomist Jason Roth. The tables below are a summary of the trial results.

Location: Gagetown, MI	**Treated Plot Size:** 6.6' x 20'
Planting Date: June 19	**N Source:** UAN (28-0-0)
Replicated: 4 times*	**S Source:** ATS (12-0-0-26)
Variety: Black Bear	**Fertilizer app:** PRE (June 24)
Population: 120,000 seeds/A	**Fungicide app:** August 2 (Propulse 10.3 fl oz)
Row width: 20-inch	**Insecticide app:** August 2 (Asana XL 9 fl oz)

Table 1. Fertilizer treatments, nitrogen rates, sulfur rates, application timing, white mold percent infection, and dry bean yield.

Treatment	Nitrogen (lb./A)	Sulfur (lb./A)	Application Timing	White Mold (% Infection)*	Yield**
1	0	0	PRE	32 ab	4446 ab
2	20	0	PRE	62 b	3855 b
3	40	0	PRE	42 ab	4292 ab
4	60	0	PRE	43 ab	4519 ab
5	80	0	PRE	33 a	4913 a
6	120	0	PRE	56 ab	3892 b
7	40	15	PRE	65 b	3752 b
8	60	15	PRE	45 ab	4459 ab

*Means within the same column with different letters are not significantly different from each other ($\alpha \leq 0.05$).
**Yield is in pounds per acres obtained by direct harvest and adjusted to 18% moisture.

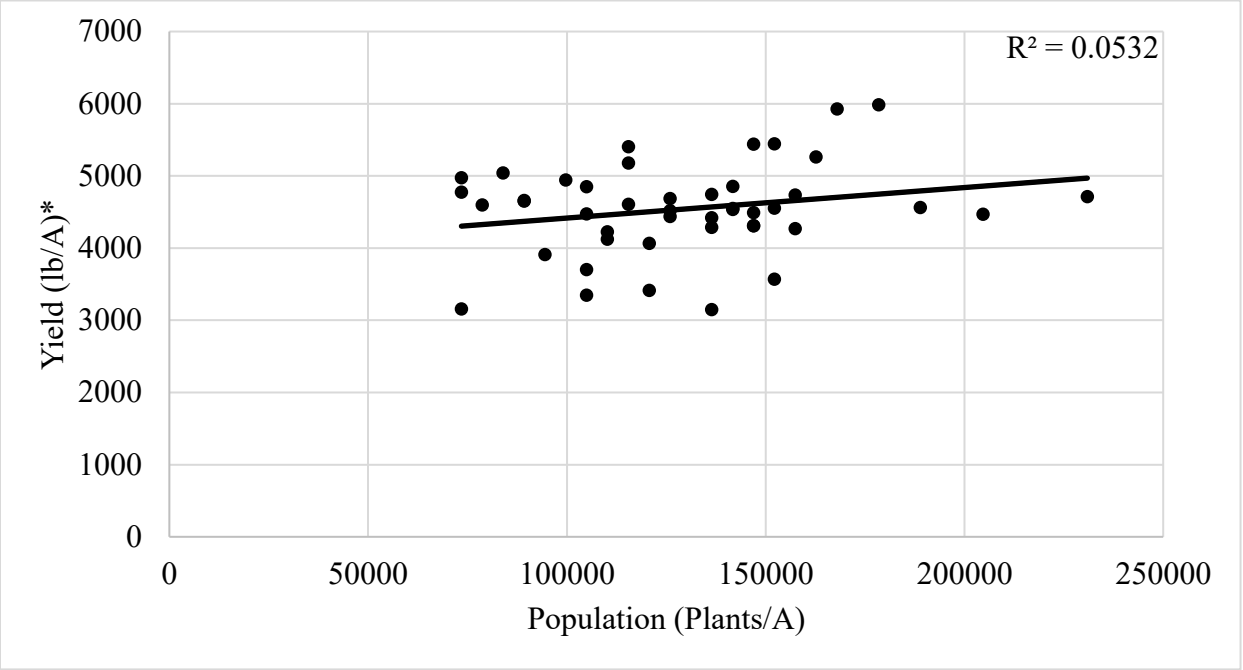
Table 2. Fertilizer treatments, nitrogen rates, sulfur rates, application timing, white mold percent infection, and dry bean yield.

Treatment	Nitrogen (lb./A)	Sulfur (lb./A)	Application Timing	Yield**
1	60	0	PRE	4644 A
2	60	10	PRE	4725 A
3	60	20	PRE	4678 A
4	60	30	PRE	4673 A
5	60	40	PRE	4218 B

*Means within the same column with different letters are not significantly different from each other ($\alpha \leq 0.05$).
**Yield is in pounds per acre obtained by direct harvest and adjusted to 18% moisture.

Cont'd PG. 19

Figure 1. Dry bean yield plotted against plant populations per acre.



*Yield is in pounds per acres obtained by direct harvest of one row plots (25 ft^2) and adjusted to 18% moisture.

Summary: Overall dry beans in this location yielded very well, more timely rains through flowering in this location kept from limiting yield potential when compared to other locations in 2019. A lack of yield response to fertilizer in both nitrogen and sulfur trials is attributed to sufficient levels of both nitrogen and sulfur in the soil prior to the establishment of these studies. An equipment error did occur at planting which caused higher populations planted by row unit number two than row unit three within the studies. However, we believe that this confounding effect did not skew dry beans response to nitrogen or sulfur in this location. Soil test taken from untreated nitrogen plots (no nitrogen applied in 2019) indicate that 20 ppm of nitrate were in the soil. This is an estimated nitrogen credit of approximately 75 lb./A, more than sufficient for optimum dry bean yield. The dry bean plant population trial in this location consisted of 41 individual one row plots. Yield was plotted against the plant population of each individual row. In this trial populations from 73,000 to 230,000 plants per acre did not create a significant trend for dry bean yield. This finding is supported by past research trials by Varner and Sprague which can be found in the 2012 research report available at Michiganbean.org. Due to the combinations of elevated base line soil fertility levels, 2019 weather patterns, and equipment errors these trials will be replicated in 2020.

Dry Bean Response to Phosphorus

Scott Bales, MSU Dry Bean Specialist

Location: Midland County (Irrigated)	**Treated Plot Size:** 6.6' x 50'
Planting Date: June 7	**P Source:** MAP (11-52-0)
Replicated: 4 times	**N Source:** Urea (46-0-0)
Variety: Black Bear & Merlin	**Fertilizer app:** PPI (June 7)
Population: 120,000 seeds/A	**Fungicide app (A):** July 24 (Propulse 10.3 fl oz)
Row width: 20-inch	**Fungicide app (B):** July 24 (Omega 8 fl oz)

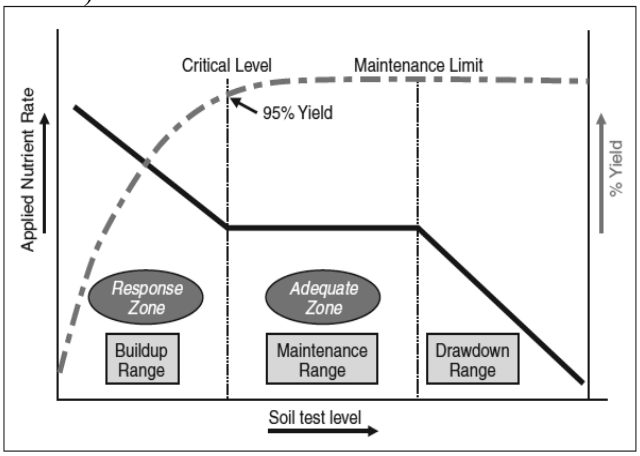
Table 1. Fertilizer treatments, nitrogen rates, phosphorus rates, and dry bean yield by market class.

Treatment	Nitrogen Rate	Phosphorus Rate	Merlin*	Black Bear
	(lb/A)	(lb/A)	Yield (lb/A)**	Yield (lb/A)
1	60	0	3553 A	3251 B
2	60	25	3354 AB	3235 B
3	60	50	3466 AB	3634 AB
4	60	100	3439 AB	3333 AB
5	60	150	3002 B	3659 A
6	60	200	3286 AB	3396 AB

*Means within the same column with different letters are not significantly different from each other ($\alpha \leq 0.05$).
**Yield is in pounds per acres obtained by direct harvest and adjusted to 18% moisture.

Summary: In 2019 a phosphorus rate response trial was established under irrigation in Midland County. Plot sizes were expanded to be four rows wide by 50 feet in length. Fertilizer treatments were blended, spread and incorporated on June 7th. Both navy and black beans planted into fertilizer treatments on June 7th. As dry beans emerged treatments with ≥150 lb. of phosphorus cause slight injury, consisting of marginal leaf burning on the unifoliate leaf of both bean classes. Overall, dry beans response to phosphorus was minimal or nonexistent. These results are supported by the pre-plant soil test which was is considered to be at levels within the "draw down" range of the response curve, 172 ppm (Figure 1).

Figure 1. Nutrient recommendation scheme for phosphorus (adopted from 'Nutrient Recommendations for Field Crops in Michigan' E2904)



Dry Bean Response to Foliar Manganese

Scott Bales, MSU Dry Bean Specialist

Location: Midland County (Irrigated)	**Treated Plot Size:** 6.6’ x 20’
Planting Date: June 7	**GPA:** 22
Replicated: 4 times	**PSI:** 60
Variety: Black Bear	**Nozzle:** TP8002VS
Population: 120,000 seeds/A	**Application A (R1):** July 24
Row width: 20-inch	**GPA:** 22

Table 1. Foliar Manganese treatments, rates, pounds of manganese applied and black bean yield.

Treatment	Product	Rate	Mn (lb/A)	Yield*
1	Untreated	-	-	4526 A**
2	Axilo Mn 13%	1 Pound	0.13	4730 A
3	Axilo Mn 13%	2 Pounds	0.26	4758 A
4	Axilo Mn 13%	3 Pounds	0.39	4816 A
5	ELE-MAX Mn 27.4%	1 Pint***	0.52	4737 A
6	ELE-MAX Mn 27.4%	2 Pint	1.04	4695 A
7	ELE-MAX Mn 27.4%	3 Pint	1.56	4402 A

*Means within the same column with different letters are not significantly different from each other ($\alpha \leq 0.05$).
**Yield is in pounds per acres obtained by direct harvest and adjusted to 18% moisture.
*** ELE-MAX contains 3% nitrogen by formulation

Summary: In 2019 a manganese deficiency was visually identified in Black Bear black beans and confirmed by an R1 tissue test. Dry beans were under irrigation, and irrigated 0.5” per week through flowering. The trial was sprayed for white mold one time (Omega 8 fl oz) to help manage white mold infection. Foliar manganese products were applied at R1 and not tank-mixed with any other products. Overall yield results were not statically significant. However, visual responses did occur for most applications. Through this study it is unclear if the foliar application of manganese at an R1 growth stage is beneficial to yield. Projects in 2020 will reexamine this management practice, as well as study multiple application timings and or tank-mixtures.

Document 1. Available soil test from 2019 research locations.

Location	OM (%)	Bray 1 (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)	pH	CEC	%K	%Mg	%Ca
BAY	1.9	35	180	270	2100	8.1	13.2	3.5	17	79.5
GRATIOT	2.2	30	121	245	1300	7.7	8.9	3.5	23.1	73.4
HURON	2.9	72	178	340	2250	7.7	14.5	3.1	19.5	77.4
MONTCALM	1.5	190	156	90	650	6.7	4.4	9.1	17	73.9
BLACK BEAN RESPONSE TO N, S, and POPULATION	2.2	76	206	355	1800	7.7	12.5	4.2	23.7	72.1
N STRIP TRIAL	2.6	46	234	445	2200	7.8	15.3	3.9	24.2	71.9
RESPONSE TO PHOSPHORUS	4.6	172	125	260	2550	7.7	15.2	2.1	14.2	83.7
SANILAC	3.9	43	153	205	1850	7.5	11.4	3.5	15.1	81.5
TUSCOLA	2.3	48	194	300	2050	7.8	13.2	3.8	18.9	77.4
WHITE MOLD (Midland)	3.6	144	148	285	2250	7.9	14	2.7	17	80.3

Document 1. Con't

Location	S (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)	B (ppm)	NH_3 (ppm)	NH_4 (ppm)
BAY	8	5.8	35	18	1.5	1	7	1
GRATIOT	8	6.5	36	19	1.9	0.8	8	1
HURON	11	9.3	26	41	4.6	1.5	12	1
MONTCALM	9	9.7	44	44	2.1	0.2	13	3
BLACK BEAN RESPONSE TO N, S, and POPULATION	10	9.6	48	22	1.8	2.1	20	2
N STRIP TRIAL	13	6.3	39	18	2.9	1.4	21	9
RESPONSE TO PHOSPHORUS	15	11.6	28	55	3.1	1.1	-	-
SANILAC	13	2.8	10	72	3	1	26	1
TUSCOLA	9	3.7	40	29	2.1	1.2	12	2
WHITE MOLD (Midland)	14	9.6	26	56	4.2	1.1	-	-

2019 MSU DRY BEAN YIELD TRIALS

J.D. Kelly, E.M. Wright and A. Wiersma

Plant, Soil and Microbial Sciences

Expt. 9101: Standard Navy Bean Yield Trial

This 25-entry trial included standard commercial navy bean varieties, and advanced lines from the MSU breeding program, which carry the N-prefix and new lines from Ontario. Yields ranged from 16.5 to 25.0 cwt/acre with a mean of 20.7 cwt/acre. Variability in this trial was moderate (CV= 10.1%) and the LSD needed for significance was 2.5 cwt/acre. However, only two lines significantly out-yielded the test mean and the overall yields were lower compared to those of black beans. Alpena was the top variety in the trial followed by Medalist, which has underperformed in past years at this location. Vigilant and Merlin grouped below the test mean. Two new entries from Ontario were opposites in yield, ACUG-16-6 was second in the trial, while AC Portage yielded at bottom with 16.5 cwt/acre. The yield potential in navy beans needs to be improved, as they are no longer competitive with black beans. Canning tests will be conducted on all new MSU breeding lines before being considered for advance.

Expt. 9102: Standard Black Bean Yield Trial-N

This 42-entry trial included the standard commercial black bean varieties and advanced breeding lines. The trial was planted without any additional N. Yields ranged from 10.7 to 25.3 cwt/acre with a test mean of 19.3 cwt/acre. Variability was moderate in this test, (CV=11.2%) and the LSD was 3.0 cwt/acre. Only three entries significantly outyielded the test mean and they included B16504 for the fourth consecutive year. Black Bear was the top variety at 20.8 cwt/acre, while Zenith, Zorro, and Eclipse yielded at the test mean. Black Tails was the lowest yielding variety at 16.2 cwt/acre. As expected, R99 no-nod line that does not fix N was the lowest yielding entry in the test. Despite the dry conditions during pod fill, a number of lines performed well in the absence of N suggesting they have improved N-fixation capacity. This trait will be evaluated in lab tests using N15 natural abundance method.

Expt. 9103: Standard Black Bean Yield Trial +N

This 42-entry trial included the same standard commercial black bean varieties and advanced breeding lines as test 9102. The trial was planted with normal N treatment of 46 lbs/acre (100 lbs urea broadcast). Yields ranged from 16.6 to 24.5 cwt/acre with a test mean of 21.7 cwt/acre. Variability was lower in this test, (CV=8.2%) and the LSD was 2.5 cwt/acre. Only two entries significantly outyielded the test mean and B18504 ranked third at 24.1 cwt/acre. Black Bear was the top variety at 23.0 cwt/acre, while Zenith ranked above the test mean. Zorro, Black Tails and Eclipse yielded below the test mean. R99 no-nod line that does not fix N was the lowest yielding

entry in the test, but yielded 7 cwt better than in test 9102 suggesting that N-fixation was important contributor to yield in the low N test 9102. The N-fixation capacity of all lines in this test will be evaluated in lab tests using N15 natural abundance method and directly compared to their N-fixation in the absence of N fertilizer. Canning tests will be conducted on new breeding lines to ensure only those with canning quality similar to Zenith are advanced.

Comparison of Black Bean Trials 9202 and 9103

A comparison of the two 42-entry black bean trials was designed to compare the performance of beans produced with no N fertilizer to those with standard N fertilizer applied (broadcast Urea at planting). The objective of this field trial was to identify black bean lines that perform well under low N conditions due to superior Nitrogen-fixation ability. In general, the yields of the fertilized treatment were slightly higher (21.7 cwt/acre) compared to those without fertilizer (19.3 cwt/acre). However, two black bean lines with exceptionally high seed yield, B17207 and B16504, had equivalent and higher yield potential under low N conditions (Figure 1). This suggests that through selection and breeding, we might be able to reduce the need for N fertilizer in Michigan dry bean production, which would have lasting and beneficial impacts on agro-environmental sustainability. Given environmental concerns, there exists a need to identify lines that naturally fix higher levels of N that contributes to yield as N application rates of over 50 lbs/acre produce higher plant biomass, which results in greater white mold infections and resulting lower yields. Higher plant biomass does not always translate into higher seed yields, but usually results in the need for chemical desiccation prior to harvest.

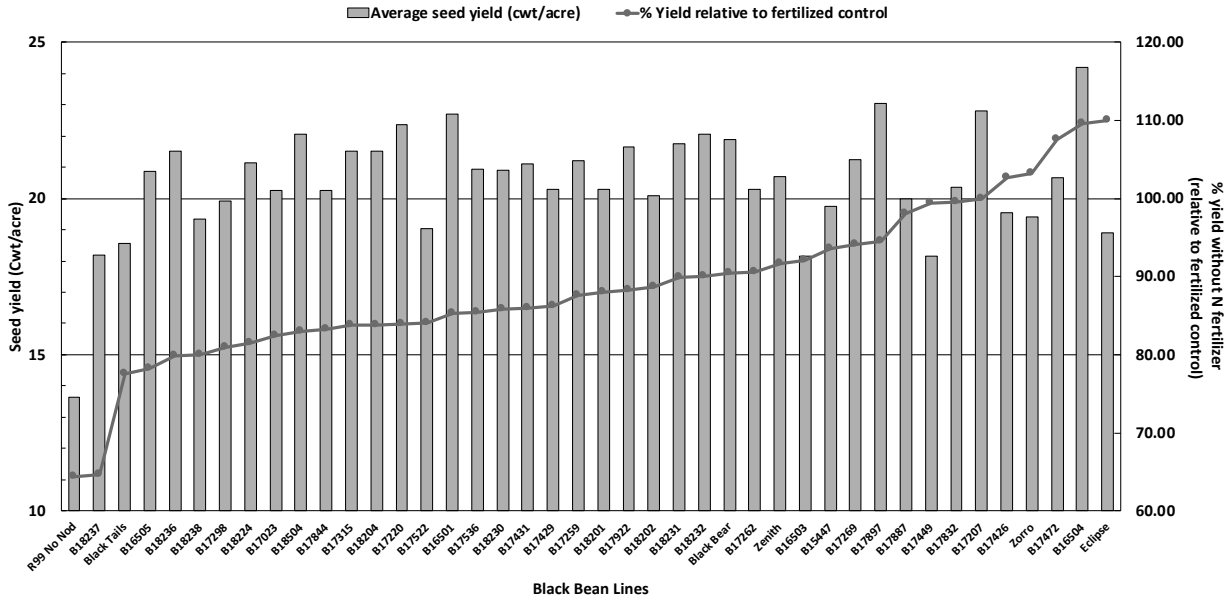


Figure 1. Comparison of average yield and % yield relative to fertilized control of 42 black bean lines tested at the Saginaw Valley Research and Extension Center, near Frankenmuth, MI.

Expt. 9215: National White Mold Yield Trial

This 32-entry trial was conducted to evaluate a range of diverse dry bean varieties and breeding lines for reaction to white mold under natural field conditions. Genotypes included commercial navy and black bean cultivars, elite MSU lines, and new sources of white mold resistance entered as part of the National *Sclerotinia* Initiative (NSI) Nursery. Lines in the National trial were developed at MSU, USDA-WA, and NDSU. Entries were planted in two row plots with two rows of susceptible spreader variety Samurai between plots and were direct harvested. Plots were fertilized with 100 lbs N/ acre to promote vegetative growth and supplemental overhead irrigation was applied 19 times for a total of 11.8" to maintain adequate levels of moisture for favorable disease development at the critical flowering period. The trial was planted on original bean land previously infected with white mold. Natural white mold infection occurred, and was very severe on both spreader rows and check varieties. White mold was rated on a per plot basis on a scale of 1 to 9 based on disease incidence and severity where 9 had 90+% incidence and high severity index. White mold ranged from 22.2 to 96.3% with a mean value of 51%. The susceptible check Beryl had the highest white mold rating. The test ranged in yield from 11.1 to 44.7 cwt/acre with a mean yield of 30.0 cwt/acre. Variability was moderate (CV=15.9%), thus a high LSD value (6.5 cwt/acre) was needed for significance. Seven lines significantly out-yielded the test mean and included Cayenne, and its parental line SR9-5 from USDA-WA. It is interesting that at this location with high-input management all the medium seeded pinto, GN and small red lines significantly outperform the small seeded black and navy bean lines. Two new R17-red lines and two new P16-pinto lines fell in the top group similar to results in 2018. G16351 and P16901 ranked 8th and 10th exceeded 36 cwt/acre despite high white mold infection levels, supporting the importance of stand ability and lodging resistance in white mold avoidance. The higher N rates coupled with excessive irrigation contributes to lodging and the higher white mold scores. Similar observations were made with the two black lines. Stand ability was a key trait in avoiding white mold in this trial and new line B18504 tended to lean due to heavy pod load and contracted higher white mold levels as a result. The trade off in erectness versus yield (pod load) is a major factor in avoidance of white mold. Interestingly the two checks, G122 resistant check yielded the same as the susceptible check Beryl (12.4 cwt/acre) yet differed in white mold infection from 22% to 96%. This trial will continue to be part of the breeding effort to improve tolerance to white mold in future varieties in 2020.

EXPERIMENT 9101 Standard Navy Yield Trial									
NAME	PEDIGREE	ENTRY NO.	YIELD CWT /ACRE	100 SEED WT.	DAYS TO FLOWER	DAYS TO MATURITY	LODGING	Planted: HEIGHT	DES. SCORE
N18103	N13120/PR00806-81	18	25.0	20.5	42.0	92.0	1.0	51.0	6.0
I19713	ACUG-16-6	24	23.3	17.5	41.0	95.0	2.0	47.7	3.0
N11283	MEDALIST/N08003, ALPENA	4	22.7	18.3	45.0	92.0	1.0	51.0	4.7
I08958	Mayflower/Avanti, MEDALIST	22	22.6	18.7	41.0	94.0	1.0	49.7	4.3
N17505	N14230/N12447	10	22.4	19.4	47.0	91.0	1.0	51.0	5.3
N18128	N15341/N14238	13	22.3	20.5	46.0	91.0	1.0	48.7	4.3
N19285	G14505/X16708	25	22.3	24.1	46.0	93.0	1.0	48.3	4.0
N18130	N15341/N14238	17	22.1	19.1	48.0	91.0	1.0	53.0	5.3
N18104	N13131/N14201	8	22.0	20.3	44.0	91.0	1.0	50.3	4.3
N18127	N14201/N13131	6	21.9	16.2	47.0	91.0	1.0	48.0	4.0
N18109	N13131/B14302	9	21.5	19.8	44.0	91.0	1.0	49.7	4.3
N18122	N15334/N15335	12	21.4	22.0	43.0	92.0	1.0	52.7	5.0
G18901	G12901/B14302	19	21.2	20.8	43.0	92.0	1.0	49.7	4.7
N18105	N13131/N14201	14	21.1	20.7	45.0	91.0	1.0	49.3	4.3
N18119	N14218/N15341	7	21.1	17.4	44.0	91.0	1.0	50.3	4.7
N17506	N14230/N12447	5	20.6	17.9	50.0	92.0	1.0	50.3	5.0
N15306	N11230/N11298	11	20.3	16.9	47.0	93.0	1.0	53.0	5.7
N18102	N13120/PR0806-81	3	20.2	19.5	43.0	91.0	1.0	49.0	5.3
N19284	G14505/X16708	21	19.9	24.7	50.0	96.0	1.0	52.3	4.3
N19289	N14243/N14218	29	19.9	18.4	49.0	92.0	1.0	49.0	5.0
N18117	N14201/N15334	2	19.7	17.0	49.0	94.0	1.0	52.7	5.0
I10101	COOP 02084, VIGILANT	15	19.6	19.0	41.0	91.0	1.0	51.7	4.3
N19283	N14243/N14218	20	19.6	18.0	50.0	92.0	1.3	52.7	5.7
N19286	G14505/X16708	26	19.6	17.9	47.0	93.0	1.3	50.0	3.7
N18116	N14201/N15334	1	19.1	17.8	47.0	92.0	1.0	53.0	5.3
N19290	N13142/B14302	30	19.1	18.3	49.0	93.0	1.3	51.0	5.7
N19288	G14505/X16705	28	18.9	21.9	45.0	91.0	1.0	47.7	4.3
I11264	COOP 03019, MERLIN	16	18.9	18.9	40.0	94.0	1.3	51.3	4.7
N19287	G14505/X16705	27	17.5	23.5	41.0	90.0	1.0	44.7	3.3
I19712	W2363X-67629BL/OAC Rex, AC PORTAGE	23	16.5	19.5	38.0	90.0	1.0	46.0	3.3
GRAND MEAN			20.7	19.5	44.8	92.1	1.1	50.2	4.6
LSD			2.5	0.7	3.3	1.4	0.3	2.0	0.6
CV			10.1	3.2	4.3	1.1	19.7	2.9	9.4

EXPERIMENT 9102 STANDARD BLACK BEAN YIELD TRIAL -N								PLANTED: 6/18/19	
NAME	PEDIGREE	ENTRY	YIELD CWT /ACRE	100 SEED WT. (g)	DAYS TO FLOWER	DAYS TO MATURITY	LODGING (1-5)	HEIGHT (cm)	DES. SCORE
B16504	Zenith//Alpena*/B09197	2	25.3	18.7	46.0	92.0	1.0	49.5	5.0
B17207	B10244/B12724	6	22.8	17.8	46.0	92.0	1.0	49.0	5.0
B17897	B14302/B10244	23	22.4	17.8	46.0	94.0	1.0	51.5	6.0
B17472	B14311/B10244	21	21.4	17.6	46.0	94.0	1.0	50.5	5.5
B16501	Zenith/B10215	7	20.9	19.7	46.0	93.0	1.0	46.5	4.5
B18232	B15430/B10244	34	20.9	20.0	45.0	92.0	1.0	49.5	5.0
I17501	BL12576, **BLACK BEAR**	39	20.8	18.3	46.0	95.0	1.0	51.0	5.0
B17269	B10244/B12724	9	20.6	19.6	46.0	91.0	1.0	46.5	4.0
B18231	B15430/B10244	32	20.6	20.0	47.0	92.0	1.0	48.5	5.0
B17220	B10244/B12724	27	20.4	18.8	44.0	93.0	1.0	48.0	4.0
B17922	B14302/B10244	16	20.3	18.7	46.0	91.0	1.0	48.5	4.5
B17832	B14302/B10244	19	20.3	17.5	47.0	94.0	1.0	46.5	3.5
B18504	Zenith//Alpena*/B09197	1	20.0	18.8	45.0	93.0	1.0	50.5	5.5
B17426	B14311/B10244	24	19.8	17.8	46.0	94.0	1.0	50.5	5.0
B17259	B10244/B12724	10	19.8	17.9	47.0	92.0	1.0	48.5	4.5
B17887	B14302/B10244	14	19.8	18.5	47.0	93.0	1.0	51.5	6.0
B10244	B04644/ZORRO, **ZENITH**	5	19.8	19.1	47.0	93.0	1.0	51.0	5.5
I03390	ND9902621-2, **ECLIPSE**	41	19.8	19.6	45.0	90.0	1.0	47.0	4.0
B04554	B00103*/X00822, **ZORRO**	38	19.7	17.8	47.0	95.0	1.0	51.5	5.0
B17315	B10244/B12724	4	19.6	17.4	48.0	94.0	1.0	52.5	5.5
B18204	B10244/B15430	30	19.6	19.7	44.0	92.0	1.0	46.0	4.0
B17431	B14311/B10244	26	19.5	17.2	47.0	92.0	1.0	47.0	4.5
B17262	B10244/B12724	13	19.3	17.8	47.0	94.0	1.0	50.5	4.5
B18230	B15428/B15418	35	19.3	20.3	49.0	93.0	1.0	46.0	4.0
B17536	B14311/B10244	18	19.3	17.4	46.0	94.0	1.0	49.0	5.0
B18236	B14303/B12724	29	19.1	17.9	46.0	92.0	1.0	47.5	5.0
B15447	B11363/Zenith	3	19.1	19.8	47.0	92.0	1.0	49.0	4.5
B18224	B15418/B10244	36	19.0	22.2	46.0	92.0	1.0	48.0	4.5
B18201	B10244/B13218	28	19.0	18.8	45.0	92.0	1.0	47.5	4.5
B18202	B10244/B13218	33	18.9	18.5	48.0	91.0	1.0	45.5	3.5
B17429	B14311/B10244	25	18.8	20.3	46.0	94.0	1.0	51.5	5.0
B17844	B14302/B10244	20	18.4	19.7	47.0	92.0	1.0	46.5	4.5
B16505	B11363//Alpena*/B09197	11	18.3	18.1	45.0	91.0	1.0	47.5	4.5
B17023	B14303/B10244	15	18.3	18.4	46.0	93.0	1.0	47.5	4.5
B17449	B14311/B10244	17	18.1	18.0	47.0	94.0	1.0	50.0	4.5
B17298	B10244/B12724	8	17.8	17.6	46.0	91.0	1.0	45.5	3.5
B17522	B14311/B10244	22	17.4	17.2	46.0	91.0	1.0	46.0	4.0
B16503	Zenith/B12720	12	17.4	20.9	47.0	92.0	1.0	47.0	4.0
B18238	B14303/B12724	37	17.2	17.7	45.0	94.0	1.0	50.0	4.5
I18625	**BLACK TAILS**	40	16.2	18.9	45.0	91.0	1.0	49.0	3.5
B18237	B14303/B12724	31	14.3	19.4	47.0	94.0	1.0	49.0	5.0
I07112	R99 NO NOD	42	10.7	17.0	46.0	98.0	2.0	47.5	3.5
MEAN(42)			19.3	18.7	45.9	92.5	1.0	48.6	4.6
LSD(.05)			3.0	0.8	1.6	1.9	0.0	3.0	1.4
CV%			11.2	3.6	2.1	1.2	1.1	3.6	18.4

EXPERIMENT 9103 STANDARD BLACK BEAN YIELD TRIAL +N								PLANTED: 6/18/19	
NAME	PEDIGREE	ENTRY	YIELD CWT /ACRE	100 SEED WT. (g)	DAYS TO FLOWER	DAYS TO MATURITY	LODGING (1-5)	HEIGHT (cm)	DES. SCORE
B16501	Zenith/B10215	7	24.5	20.1	47.0	93.0	1.0	50.5	5.0
B17220	B10244/B12724	27	24.3	19.4	45.0	92.0	1.0	49.0	4.5
B18504	Zenith//Alpena*/B09197	1	24.1	19.7	46.0	93.0	1.0	50.5	5.5
B18236	B14303/B12724	29	23.9	19.9	46.0	92.0	1.0	49.0	5.0
B17897	B14302/B10244	23	23.7	18.4	46.0	92.0	1.0	48.5	4.5
B16505	B11363//Alpena*/B09197	11	23.4	19.6	46.0	92.0	1.0	48.0	5.0
B18204	B10244/B15430	30	23.4	21.0	45.0	93.0	1.0	49.5	5.5
B18224	B15418/B10244	36	23.3	23.8	46.0	93.0	1.0	50.5	5.5
B18232	B15430/B10244	34	23.2	21.0	46.0	92.0	1.0	50.5	5.0
B16504	Zenith//Alpena*/B09197	2	23.1	19.4	45.0	93.0	1.0	52.0	6.0
I17501	BL12576, **BLACK BEAR**	39	23.0	18.8	46.0	95.0	1.0	50.5	5.0
B17922	B14302/B10244	16	23.0	18.8	46.0	92.0	1.0	49.5	5.0
B18231	B15430/B10244	32	22.9	21.0	47.0	93.0	1.0	49.5	5.5
B17207	B10244/B12724	6	22.8	18.2	46.0	92.0	1.0	48.0	4.5
B17431	B14311/B10244	26	22.7	18.7	46.0	92.0	1.0	49.0	5.0
B17259	B10244/B12724	10	22.6	19.5	47.0	93.0	1.0	50.0	5.0
B17536	B14311/B10244	18	22.6	19.2	47.0	93.0	1.0	49.0	4.5
B18230	B15428/B15418	35	22.5	22.7	45.0	92.0	1.0	47.5	4.5
B17023	B14303/B10244	15	22.2	19.6	45.0	93.0	1.0	49.0	4.5
B17844	B14302/B10244	20	22.1	19.2	47.0	93.0	1.0	48.0	5.0
B18237	B14303/B12724	31	22.1	21.6	45.0	94.0	1.0	50.5	5.5
B17298	B10244/B12724	8	22.0	18.9	46.0	91.0	1.0	47.0	4.0
B17269	B10244/B12724	9	21.9	19.8	47.0	92.0	1.0	48.0	4.0
B17429	B14311/B10244	25	21.8	21.7	47.0	94.0	1.0	53.5	5.5
B10244	B04644/ZORRO, **ZENITH**	5	21.6	19.9	47.0	93.0	1.0	50.5	5.5
B18201	B10244/B13218	28	21.6	19.1	46.0	92.0	1.0	48.0	4.5
B18238	B14303/B12724	37	21.5	19.3	45.0	91.0	1.0	47.5	4.5
B17262	B10244/B12724	13	21.3	18.3	47.0	94.0	1.0	51.5	5.5
B18202	B10244/B13218	33	21.3	19.8	46.0	93.0	1.0	50.5	5.0
I18625	**BLACK TAILS**	40	20.9	20.3	45.0	92.0	1.0	49.0	4.0
B17522	B14311/B10244	22	20.7	18.8	46.0	92.0	1.0	48.5	4.5
B17315	B10244/B12724	4	20.5	17.7	47.0	95.0	1.0	50.0	4.5
B17832	B14302/B10244	19	20.4	18.5	47.0	93.0	1.0	50.0	5.0
B15447	B11363/Zenith	3	20.4	19.7	45.0	91.0	1.0	49.0	4.5
B17887	B14302/B10244	14	20.2	20.1	49.0	94.0	1.0	51.5	5.0
B17472	B14311/B10244	21	19.9	18.6	46.0	93.0	1.0	47.5	4.0
B17426	B14311/B10244	24	19.3	19.2	47.0	94.0	1.0	51.0	5.5
B04554	B00103*/X00822, **ZORRO**	38	19.1	18.7	48.0	95.0	1.0	52.0	5.0
B16503	Zenith/B12720	12	18.9	22.6	47.0	91.0	1.0	48.5	4.0
B17449	B14311/B10244	17	18.2	18.9	47.0	93.0	1.0	50.0	4.0
I03390	ND9902621-2, **ECLIPSE**	41	18.0	18.4	45.0	91.0	1.0	49.0	4.0
I07112	R99 NO NOD	42	16.6	18.8	45.0	98.0	2.0	48.5	3.5
MEAN(42)			21.7	19.7	46.0	92.6	1.0	49.5	4.8
LSD(.05)			2.5	0.9	1.6	1.6	0.0	2.6	1.1
CV%			8.2	4.1	2.1	1.0	1.1	3.1	13.2

EXPERIMENT 9215 National White Mold Yield Trial											
NAME	PEDIGREE	ENTRY NO.	YIELD CWT /ACRE	100 SEED WT.	DAYS TO FLOWER	DAYS TO MATURITY	LODGING	Planted: HEIGHT	DES. SCORE	WM	WM%
G17410	G13467/G13479	23	44.7	38.7	44.0	102.0	1.0	53.3	5.3	2.3	25.9
R17605	R12859/R12844	32	42.0	36.3	50.0	102.0	2.3	51.3	4.0	5.3	59.2
P17510	SDP H/H BULK	26	39.5	43.8	47.0	98.0	2.0	52.3	4.3	5.7	63.0
R12844	SR9-5/R09508, CAYENNE	27	39.2	37.3	48.0	97.0	2.3	51.3	4.3	3.7	40.7
P16905	P11519/P12610	25	38.1	43.8	49.0	95.0	1.3	51.7	5.7	3.0	33.3
R17603	R12859/R12844	31	38.0	37.6	50.0	101.0	1.7	52.3	5.3	3.7	40.7
I09203	SR9-5	4	37.1	34.5	47.0	105.0	2.3	51.7	4.0	3.3	37.0
G16351	Eldorado/G13467	6	36.2	38.6	46.0	96.0	2.0	52.7	4.0	7.0	77.8
N18122	N15334/N15335	16	36.2	26.3	49.0	102.0	1.3	57.0	6.0	3.7	40.7
P16901	Eldorado/P11519	7	36.1	41.5	50.0	97.0	1.7	51.0	5.0	5.0	55.5
I19714	ND112929	10	35.4	41.8	48.0	95.0	1.7	51.3	4.3	4.7	51.9
I19701	NDF120287	9	34.4	24.7	47.0	93.0	1.7	47.3	4.0	3.0	33.3
R17604	R12859/R12844	8	33.0	34.7	50.0	100.0	2.0	51.7	4.7	5.0	55.5
G18505	G14506/G13444	24	32.5	34.8	45.0	92.0	1.0	50.3	5.3	4.7	51.9
B18201	B10244/B13218	22	31.7	21.9	48.0	95.0	1.3	50.0	4.3	6.0	66.7
B17922	B14302/B10244	20	31.3	22.7	49.0	95.0	1.0	51.7	5.0	4.0	44.4
N18117	N14201/N15334	17	31.2	21.1	49.0	105.0	2.0	54.0	5.0	2.7	29.6
B10244	B04644/ZORRO, ZENITH	28	31.1	24.2	47.0	94.0	1.0	51.0	5.3	5.3	59.3
B16504	Zenith//Alpena*/B09197	18	30.9	21.2	49.0	98.0	1.0	53.3	5.0	4.3	48.1
B18204	B10244/B15430	21	28.8	24.7	48.0	94.0	1.0	49.7	5.0	3.7	40.7
G08254	G04514/Matterhorn, POWDERHORN	30	28.0	36.6	44.0	91.0	1.3	47.7	5.0	3.0	33.3
B18231	B15430/B10244	12	27.8	24.8	49.0	95.0	1.0	53.3	5.3	4.3	48.1
B18504	Zenith//Alpena*/B09197	19	27.6	22.7	49.0	98.0	1.3	50.0	4.7	4.0	44.4
N18102	N13120/PR0806-81	14	25.9	23.2	50.0	95.0	1.7	52.7	4.3	6.0	66.7
I11264	COOP 03019, MERLIN	29	25.5	20.0	46.0	99.0	2.0	49.3	4.0	4.7	51.9
I08933	37-2, USPT-WM-12	5	24.7	45.3	45.0	94.0	1.7	48.3	4.3	4.0	44.4
N18109	N13131/B14302	15	21.2	23.2	49.0	96.0	1.3	51.7	4.3	7.0	77.8
N17506	N14230/N12447	13	18.8	21.7	49.0	94.0	1.3	51.0	4.3	6.3	70.4
I81010	JAPON3/MAGDALENE, BUNSI	1	16.9	21.6	44.0	94.0	3.7	43.7	3.0	6.3	70.4
I96417	G122 MAGNUSON	3	12.4	44.9	48.0	106.0	1.0	46.7	2.3	2.0	22.2
I89011	RB, BERYL	2	12.4	32.8	43.0	91.0	5.0	40.0	2.0	8.7	96.3
Y16507	PR1146-123/Y11405	11	11.1	44.0	45.0	93.0	1.0	46.7	4.0	3.7	40.7
GRAND MEAN			30.0	31.6	47.2	96.9	1.7	50.5	4.5	4.6	50.7
LSD			6.5	2.3	1.9	2.7	0.6	2.7	0.9	2.6	29.3
CV			15.9	5.4	2.4	2.0	27.2	3.9	14.1	42.4	42.4

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan State University AgBioResearch

Response of Dry Bean to Nitrogen Application

Christian Terwillegar, Andrew Chomas, and Kurt Steinke, Michigan State University

See soil.msu.edu for more information

Location: Saginaw Valley Research and Extension Center	**Tillage**: Conventional
Planting Date: June 19, 2019 (Harvest 09/25/19)	**Row Width**: 20-inch
Soil Type: Clay Loan; 2.6% OM; 7.8 pH; 8 ppm P (Olsen); 124 ppm K	**Trts**: See below
Varieties: Zenith (black bean), Black Bear (black bean)	**Population**: 5 ½ in. spacing
Viper (small red bean), Merlin (navy bean)	**Replicated**: 4 replications

N Rate (Total lb. N/A)	Yield[b] (cwt/A)	Biomass[c] (lbs/A)	Nodule Count[d] (nodules/plant)
0 N	23.2	3,650	4.3
30 N	21.1	4,231	3.2
60 N	22.0	4,692	1.9
90 N	23.4	5,229	2.6
120 N	22.8	4,654	0.9
150 N	23.4	5,314	1.0
$LSD_{(0.10)}$[a]	**NS**	**607**	**NS**

[a] LSD, least significant difference between means within a column at (α=0.10)
[b] Yield adjusted to 18% moisture.
[c] Total biomass accumulation collected at R5.
[d] Average number of nodules on a per plant basis obtained 6 weeks after emergence.

Summary: Trial quality was fair to good as some soil borne disease pressure unrelated to treatments was evident at emergence. Treatments consisted of four dry bean varieties: Zenith (black bean), Black Bear (black bean), Viper (small red bean), and Merlin (navy bean). Urea was pre-plant incorporated at nitrogen rates of 0, 30, 60, 90, 120, and 150 lb. N/A. Cumulative growing season precipitation (June-September) totaled 14.2 inches and was near the 30 year mean. However, June rainfall was 97% greater and August rainfall was 67% reduced as compared to the 30 year means, respectively. Pre-plant residual soil N was 18 lbs. N/A available in the top one foot of soil. Variety did not affect response to N applications thus data were combined across varieties. Wet emergence conditions combined with lack of August rainfall likely decreased yield potential, overall growth, and total N uptake. No yield differences occurred due to N application at this location. Total biomass production significantly differed by N rate, but results did not correspond to yield. Biomass accumulation did not differ beyond 60 lb. N/A. Nodulation counts per plant were not significantly impacted by N applications but data were highly variable. Biomass accumulation may not translate directly into additional yield potential. Thus do not confuse an aboveground plant growth response with a grain yield response. Applying above recommended N rates may increase biomass production resulting in decreased air movement and greater pathogen growth. Trial will repeated in 2020.

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan State University AgBioResearch

Dry Bean Response to Phosphorus Application

Kurt Steinke and Andrew Chomas, Michigan State University

See soil.msu.edu for more information

Location: Saginaw Valley Research and Extension Center	**Tillage**: Conv., 20-in. row
Planting Date: June 19, 2019 (Harvest 9/25/19)	**P Rates**: See below
Soil Type: Clay loam; 2.6% OM; 7.8 pH; 8 ppm P (Olsen); 124 ppm K;	**Population**: 5 ½ in. spacing
Varieties: Zenith (black bean), Black Bear (black bean)	**Replicated**: 4 replications
Viper (small red bean), Merlin (navy bean)	

P Trt. (Total lb. P_2O_5/A)	Yield[b] (cwt/A)
0 – Check	25
25	23
50	23
100	21
150	22
200	23
$LSD_{(0.10)}$[a]	**NS**

[a] LSD, least significant difference between means within a column at ($\alpha = 0.10$).

[b] Yield adjusted to 18% moisture.

Summary: Trial quality was fair to good. Phosphorus source was monoammonium phosphate (MAP, 11-52-0) applied pre-plant incorporated with N contributions from the MAP accounted for in overall total N application rates. All treatments received 60 lbs. N/A total. Variety did not affect response to P applications thus data were combined across varieties. Two inches of rainfall within 48 hours of planting resulted in some crusting and emergence issues. Lack of soil moisture during August (1.06 inches rainfall) likely limited both nutrient availability and plant growth. No yield differences occurred across the spectrum of P application rates in this study. Critical Bray-P soil test concentration for dry bean is 15 ppm with a maintenance range of 15-40 ppm. When converting the Olsen P measurement to the Bray P equivalent, this location resulted in a soil test P concentration slightly above the critical level of 15 ppm. Dry soil conditions likely limited P availability, plant growth, and yield potential thus limiting response to P applications. Trial will be repeated in 2020. Don't Guess Soil Test! Have a current soil test report on hand for the coming season and decide on the likelihood of observing a P grain yield response prior to making any 2020 fertilizer decisions.

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan State University AgBioResearch

Dry Bean Response to Potassium Application

Kurt Steinke and Andrew Chomas, Michigan State University

See soil.msu.edu for more information

Location: Saginaw Valley Research and Extension Center	**Tillage**: Conv., 20-in. row
Planting Date: June 19, 2019 (Harvest 9/25/19)	**K Rates**: See below
Soil Type: Clay loam; 2.6% OM; 7.8 pH; 8 ppm P (Olsen); 124 ppm K	**Population**: 5 ½ in. spacing
Varieties: Zenith (black bean), Black Bear (black bean)	**Replicated**: 4 replications
Viper (small red bean), Merlin (navy bean)	

K Trt. (Total lb. K_2O/A)	Yield[b] (cwt/A)
0 – Check	24
25	25
50	24
100	26
150	23
200	24
$LSD_{(0.10)}$[a]	**NS**

[a] LSD, least significant difference between means within a column at ($\alpha = 0.10$).

[b] Yield adjusted to 18% moisture.

Summary: Trial quality was fair to good. Potassium source was potassium chloride (MOP, 0-0-60) applied pre-plant incorporated. All treatments received 60 lbs. N/A total as urea applied pre-plant incorporated. Variety did not affect response to K applications thus data were combined across varieties. Critical soil test K concentration for dry bean at this location was 112 ppm with a maintenance range of 112-142 ppm. Due to residual soil test K concentrations, no yield differences occurred across the spectrum of K application rates in this study nor was a yield response expected. Differences in overall biomass growth were observed in response to K application but did not correspond to yield. Two inches of rainfall within 48 hours of planting resulted in some crusting and emergence issues. Lack of soil moisture during August (1.06 inches rainfall) likely limited both nutrient availability and plant growth. Although no visual K tissue deficiencies were observed during the course of this study, the dry soil conditions likely limited the diffusive movement of K to plant roots thus further limiting the effectiveness of the fertilizer applications. Trial will be repeated in 2020. Don't Guess Soil Test! Have a current soil test report on hand for the coming season and consider the current soil test K concentration, the likelihood of yield response, and the rate of drawdown prior to making 2020 fertilizer decisions.

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan State University AgBioResearch

Sulfur Rate and Source Response for Dry Bean

Christian Terwillegar, Andrew Chomas, and Kurt Steinke, Michigan State University
See soil.msu.edu for more information

Location: Saginaw Valley Research and Extension Center	**Tillage**: Conventional
Planting Date: June 19, 2019 (Harvest 09/25/19)	**Row Width**: 20-inch
Soil Type: Clay Loan; 2.6% OM; 7.8 pH; 8 ppm P (Olsen); 124 ppm K	**Trts**: See below
Varieties: Zenith (black bean), Black Bear (black bean)	**Population**: 5 ½ in. spacing
Viper (small red bean), Merlin (navy bean)	**Replicated**: 4 replications

S Rate (Total lb. S/A)	Yield[b] (cwt/A)	NDVI[c]	Nodule Count[d] (nodules/plant)
CHECK	21.8	0.63	4.3
25 S	22.1	0.61	3.2
50 S	22.1	0.66	1.9
100S	21.8	0.62	2.6
$LSD_{(0.10)}$[a]	**NS**	**NS**	**NS**

[a]LSD, least significant difference between means within a column at (α=0.10)
[b]Yield adjusted to 18% moisture.
[c]NDVI data collection occurred on 18 Jul 2019.
[d]Average number of nodules on a per plant basis obtained 6 weeks after emergence.

S Source (25 lb. S/A)	Yield[b] (cwt/A)	NDVI[c]
Gypsum	22.1	0.62
AMS	20.4	0.62
MESZ	19.8	0.57
$LSD_{(0.10)}$[a]	**NS**	**0.02**

[a]LSD, least significant difference between means within a column at (α=0.10)
[b]Yield adjusted to 18% moisture.
[c]NDVI data collection occurred on 18 Jul 2019.

Summary: Trial quality was fair to good. Treatments consisted of four dry bean varieties: Zenith (black bean), Black Bear (black bean), Viper (small red bean), and Merlin (navy bean). Gypsum was utilized as the S source within the S rate study and was pre-plant incorporated at 0, 25, 50, and 100 lb. S/A. For the S source study, gypsum, AMS (21-0-0-24), and MESZ (12-40-0-10-1) were utilized as S sources and pre-plant incorporated at 25 lb. S/A. Nitrogen was balanced to 60 lb. N/A for all treatments in the form of pre-plant incorporated urea. Variety did not affect response to S rate or sources thus data were combined across varieties. Yield, NDVI, and nodulation counts were not affected by S rate in this study. Wet planting conditions and limited precipitation in August limited plant growth, development, and yield. NDVI responded to S source but no yield response occurred. Trial will repeated in 2020.

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan State University AgBioResearch

Manganese and Zinc Application in Dry Bean

Kurt Steinke and Andrew Chomas, Michigan State University

See soil.msu.edu for more information

Location: Saginaw Valley Research and Extension Center	**Tillage**: Conv., 20-in. row
Planting Date: June 19, 2019 (Harvest 9/25/19)	**K Rates**: See below
Soil Type: Clay loam; 2.6% OM; 7.8 pH; 8 ppm P (Olsen); 124 ppm K 37 ppm Mn; 3.7 pm Zn	**Population**: 5 ½ in. spacing
Variety: Zorro (black bean)	**Replicated**: 4 replications

Mn Trt. (Total lb. Mn/A)	Yield[b] (cwt/A)
0 – Check	21
1 (25 DAE)	22
1 (25 DAE) 1 (35 DAE)	23
LSD$_{(0.10)}$[a]	**NS**

[a] LSD, least significant difference between means within a column at (α = 0.10).
[b] Yield adjusted to 18% moisture.

Zn Trt. (Total lb. Zn/A)	Yield[b] (cwt/A)
0 – Check	24
5	25
10	23
LSD$_{(0.10)}$[a]	**NS**

[a] LSD, least significant difference between means within a column at (α = 0.10).
[b] Yield adjusted to 18% moisture.

Summary: Trial quality was fair to good. Manganese was foliar applied using a 5% soluble Mn solution at rates of 1 lb Mn/A at 25 days after emergence and another treatment as 1 lb Mn/A at 25 and 35 days after emergence (2 lb Mn/A total). Zinc was pre-plant incorporated using zinc sulfate at 5 and 10 lb Zn/A. All treatments received 60 lbs. N/A total as urea applied pre-plant incorporated. Critical soil test Mn concentrations for dry bean on mineral soils are near 6 ppm at a 6.3 soil pH and 12 ppm at a 6.7 soil pH. At the current soil test level of 37 ppm, a yield response to Mn was not expected. Under dry soil conditions such as those observed in July and

August 2019, Mn availability is reduced due to decreased rates of diffusion to the root and increases in the oxidized, less available form of Mn (Mn^{4+}). Despite some visual confirmation of Mn tissue deficiency during the dry mid-summer period, dry bean plants did not respond to the foliar Mn treatments at this location. Visual tissue deficiencies dissipated upon receiving rainfall.

Critical soil test Zn concentrations for dry bean are near 2 ppm at 6.6 soil pH and 7 ppm at 7.0 soil pH. At the current soil test level of 3.7 ppm, a yield response to Zn application was probable but not realized during the 2019 growing season at this location. Zinc is predominately transported within the rooting zone by diffusion, and the lack of sufficient mid-summer soil moisture coinciding with peak dry bean growth likely limited the effectiveness and uptake of the Zn fertilizer application. Due to the diffusive movement of Zn in the soil, banded Zn applications at planting are often preferred as compared to broadcast pre-plant applications. Both trials will be repeated in 2020.

Rhizoctonia Root Rot on Dry Bean

Dr. Martin Chilvers and Janette Jacobs
Michigan State University
Department of Plant, Soil and Microbial Sciences

The growing season of 2019 was a year for *Rhizoctonia solani* to rear its ugly head and cause plant death in a number of Michigan dry bean fields. Symptomatic plant samples were collected by Dr. Jim Kelly, from fields located in Alpena, Huron and Saginaw counties showing single plants or areas with plant death. Isolations from roots and lower stems resulted in recovery of *Rhizoctonia solani* from 15/20 plant samples.

Pathogens such as *R. solani* and certain *Pythium* spp. are generally thought to be more of an issue during plant establishment, causing seed rot and damping-off of emerging seedlings, resulting in stand loss (Conner et al. 2014). However, infection by *R. solani* can also result in the formation of stem cankers later in the growing season. In 2019, we saw these later symptoms develop, resulting in plant death before full maturity.

The diversity of *R. solani* multinucleate anastomosis groups causing disease symptoms on dry bean has not been well studied. An anastomosis grouping study of *R. solani* isolates recovered from dry bean in the state of Ohio and the Democratic Republic of the Congo, identified AG-2-2 IIIB and AG-4, respectively (Muyolo et al. 1993). A more recent study in Nebraska, identified the multinucleate AG-2-2, AG-4, AG-5 and the binucleate AG-K (Adesemoye et al. 2018). Our group has conducted a five-year survey on the root rot pathogens associated with dry bean in Michigan, to date the following anastomosis groups have been identified (Table 1). Thus showing the vast diversity of *Rhizoctonia* AG present in Michigan fields.

Table 1. The anastomosis groups of *Rhizoctonia solani* isolated from dry bean in Michigan from 2014-2018.

Anastomosis Group (AG)	**Frequency AG recovered (%)**
Multinucleate *Rhizoctonia*	
AG-2-2	109 (60%)
AG-4	6 (3.3%)
AG-5	24 (13.2%)
AG-10	4 (2.2%)
AG-11	5 (2.7%)
Binucleate *Rhizoctonia*	
AG-A	19 (10.4%)
AG-E	2 (1.1%)
AG-F	2 (1.1%)
AG-G	2 (1.1%)
AG-K	6 (3.3%)
AG-E	5 (2.7%)

Further work is ongoing to identify the genetic diversity associated with *R. solani*, evaluate seed rot and seedling pathogenicity across the genetic diversity, and determine the various edaphic and climatic conditions that influence distribution of this important soilborne pathogen.

The root rot survey provided baseline information regarding the prevalence of critical soilborne pathogens associated with commercial dry bean production in Michigan. These initial findings were published in Plant Health Progress 20:122-127. Jacobs et al., 2019, "Determining the Soilborne Pathogens Associated with Root Rot Disease Complex of Dry Beans in Michigan". Below is a summary table of the survey indicating the number of field locations, counties and the number and percentages of root rot pathogens by major groups recovered.

Table 2. Number and percent of each root rot pathogen group isolated from dry bean by year and county, from 2014-2018 in Michigan.

Year	County	Number of Sites	Number of Plant Samples	Number (percentage) of Isolates			
				***Fusarium* spp.**	***Rhizoctonia solani***	**Oomycetes**	**Total Number of Isolates**
2014	**Ingham**	**1**	**34**	**10 (43.5)**	**5 (21.7)**	**8 (34.8)**	**23**
	Montcalm	**4**	**46**	**32 (45.1)**	**22 (31.0)**	**17 (23.9)**	**71**
	Saginaw	**1**	**34**	**10 (23.3)**	**31 (72.1)**	**2 (4.6)**	**43**
	Sanilac	**1**	**1**	**1 (50.0)**	**0**	**1 (50.0)**	**2**
	Total	7	115	53 (38.1)	58 (41.8)	28 (20.1)	139
2015	**Gratiot**	**2**	**41**	**35 (67.3)**	**8 (15.4)**	**9 (17.3)**	**52**
	Huron	**3**	**68**	**47 (43.5)**	**31 (28.7)**	**30 (27.8)**	**108**
	Ingham	**1**	**10**	**7 (35.0)**	**4 (20)**	**9 (17.3)**	**20**
	Montcalm	**3**	**97**	**45 (34.5)**	**41 (31.2)**	**45 (34.4)**	**131**
	Saginaw	**4**	**89**	**52 (47.7)**	**19 (17.4)**	**38 (34.9)**	**109**
	Sanilac	**1**	**20**	**14 (41.2)**	**14 (41.2)**	**6 (17.6)**	**34**

	Total	14	325	200 (44.1)	117 (25.7)	137 (30.2)	454
2016	**Bay**	**2**	**20**	**35 (79.5)**	**7 (16.0)**	**2 (45.5)**	**44**
	Gratiot	**1**	**10**	**10 (43.5)**	**8 (34.8)**	**5 (21.7)**	**23**
	Ingham	**1**	**3**	**0 (0.0)**	**0 (0.0)**	**4 (100.0)**	**4**
	Total	4	33	45 (63.4)	15 (21.1)	11 (15.5)	**71**
2017	**Ingham**	**1**	**10**	**22 (88.0)**	**3 (12.0)**	**0 (0.0)**	**25**
	Montcalm	**4**	**38**	**49 (52.1)**	**11 (11.7)**	**34 (36.2)**	**94**
	Tuscola	**2**	**45**	**82 (76.7)**	**7 (6.5)**	**18 (16.8)**	**107**
	Total	7	93	153 (67.7)	21 (9.3)	52 (23.0)	226
2018	**Alcona**	**3**	**10**	**33 (70.2)**	**7 (14.9)**	**7 (14.9)**	**47**
	Presque Isle	**4**	**25**	**74 (76.3)**	**14 (14.4)**	**9 (9.3)**	**97**
	Total	7	35	107 (74.3)	21 (14.6)	16 (11.1)	144

Phenotypic characterization has been conducted and is currently being analyzed to assess pathogenicity and virulence of these organisms on dry bean.

In addition, collaborative efforts with Dr. Jim Kelly, Dr. Ali Soltani, and Dr. Karen Cichy have been undertaken to identify resistant markers using phenotypic selection to pathogens. In addition, field screening of germplasm to *Rhizoctonia solani*, *Fusarium brasiliense*, *Fusarium oxysporum* and *Pythium ultimum* was conducted to evaluate resistance under field conditions.

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan State University AgBioResearch

Preharvest treatments for dry bean desiccation

Christy Sprague, Gary Powell and Brian Stiles, Michigan State University

Location:	Shiawassee County	**Tillage:**	Conventional
Planting Date:	June 29, 2019	**Row width:**	20-inch
Replicated:	4 times	**Population:**	105,000 seeds/A
Varieties:	'Zenith' black beans	**Desiccation date:**	Sept. 24, 2019

Table 1. Preharvest treatments on 'Zenith' black bean leaf, pod, and stem desiccation (%) 3, 7, 14 days after treatment (DAT).

		7 DAT			
Treatments	**3 DAT**	**leaf**	**pod**	**stem**	**14 DAT**
Homeplate (3% v/v)	70 b[a]	76 b	74 c	78 bc	88 b
Homeplate (5% v/v)	71 b	79 b	74 c	78 bc	89 b
Homeplate (7% v/v)	69 b	75 b	70 c	71 c	87 b
Sharpen (1 fl oz) + MSO + AMS	82 a	96 a	99 a	93 a	100 a
Gramoxone 3L (1.33 pt) + NIS	86 a	91 a	87 b	83 b	94 a
Sharpen (1 fl oz) + Gramoxone 3L (1.33 pt) + MSO + AMS	89 a	96 a	98 a	94 a	99 a
Untreated	58 c	63 c	71 c	72 c	83 b

[a] Means within a column with different letters are significantly different from each other.

Summary: The objective of this research was to examine dry bean desiccation under challenging conditions by comparing popular desiccation treatments with a potential new option for dry bean desiccation, Homeplate. Homeplate (44% Caprylic acid:36% Capric acid) is a new non-selective organic herbicide. The research was conducted in Shiawassee County since many dry bean farmers in this area are always challenged with uniform dry down of beans. All preharvest treatments were applied when dry beans pods were at 70-80% yellow at 19 gallons per acre to insure good uniform spray coverage. Dry bean desiccation with Homeplate was not rate dependent. While this herbicide was not as effective as currently registered products, Homeplate did provide greater overall plant desiccation 3 DAT and greater leaf desiccation 7 DAT than the untreated control. While this may not be a replacement desiccation product for conventional dry bean growers, Homeplate may have a good fit as a desiccant for organic dry beans. Only slight desiccation differences were observed between the application of Sharpen and Gramoxone alone. These occurred mostly with pod and stem desiccation 7 DAT. While there was no difference when comparing Sharpen alone with Sharpen + Gramoxone in this trial, the benefits of adding Gramoxone to Sharpen have been observed in previous trials and this combination will also aid in the control of weeds that are present at application. In this trial we used the new formulation of Gramoxone 3L, that is why the use rate is different as compared with previous years where a 2 lb ai/gallon product was used. Additionally, keep in mind if you are using Gramoxone it is a **Restricted Use Pesticide** and that there are new requirements for training prior to its use. These requirements and more information on preharvest treatments for dry beans can be found in the 2020 MSU Weed Control Guide (E-434). This research was supported by the Michigan Dry Bean Commission through the Michigan Department of Agriculture Specialty Crops grant.

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan State University AgBioResearch

Preharvest herbicides for common lambsquarters desiccation in dry beans

Christy Sprague, Gary Powell and Brian Stiles, Michigan State University

Location:	Richville (SVREC)	**Tillage:**	Conventional
Planting Date:	June 19, 2019	**Row width:**	30-inch
Replicated:	4 times	**Dates treated:**	Sept. 16 (80% pods yellow)
Varieties:	'Merlin' navy beans		Sept. 19 (+3 days)

Table 1. Effect of preharvest treatments on common lambsquarters desiccation (%).

	Common lambsquarters	
Treatments	**7 DAT[a]**	**14 DAT**
Homeplate (3% v/v)	4 de[b]	4 d
Homeplate (5% v/v)	5 de	4 d
Homeplate (7% v/v)	6 de	6 d
Sharpen (1 fl oz) + MSO + AMS	8 d	6 d
Gramoxone 3L (1.33 pt) + NIS	94 ab	94 a
Valor (1.5 oz) + MSO	8 d	6 d
Roundup (22 fl oz) + AMS	63 c	75 c
Aim (2 fl oz) + MSO	3 de	5 d
Sharpen (1 oz) + Gramoxone 3L (1.33 pt) + MSO + AMS	89 a	85 b
Valor (1.5 oz) + Gramoxone 3L (1.33 pt) + MSO + AMS	83 b	79 bc
Aim (2 fl oz) + Gramoxone 3L (1.33 pt) + MSO + AMS	96 a	96 a
Sharpen (1 fl oz) + MSO + AMS fb. Sharpen (1 fl oz) + MSO + AMS	85 b	88 b
Sharpen (1 fl oz) + MSO + AMS fb. Gramoxone 3L (1.33 pt) + NIS	86 b	88 b
Gramoxone 3L (1.33 pt) + NIS fb. Sharpen (1 fl oz) + MSO + AMS	96 a	94 a
Untreated	0 e	0 d

[a] Abbreviations: DAT = days after treatment, MSO = methylated seed oil, AMS = ammonium sulfate, NIS = non-ionic surfactant

[b] Means within a column with different letters are significantly different from each other

Summary: This study was conducted to evaluate the effects of preharvest herbicide treatments on weed and bean desiccation. Dry bean desiccation (dry down) was uniform across all treatments including the untreated control, so bean desiccation could not be evaluated in this trial. Uniform dry down was likely due to drier conditions at SVREC as the beans matured. One new product that we examined was Homeplate (44% Caprylic acid:36% Capric acid) a new non-selective organic herbicide. This herbicide had very little effect on lambsquarters desiccation. Gramoxone alone, in combination, or in sequential applications were the most consistent for common lambsquarters desiccation. While these results were fairly consistent, we did observe some slight differences, depending on tank-mix partner. Over the years if you are trying desiccate weeds, including Gramoxone in preharvest treatment has been the most consistent. Please be aware if you are using Gramoxone there are new requirements for training prior to use. These requirements and more information on preharvest treatments for dry beans can be found in the 2020 MSU Weed Control Guide (E-434). This research was supported by the Michigan Dry Bean Commission through the Michigan Department of Agriculture Specialty Crops grant.

TABLE 5A – Weed Response to Herbicides in Dry Edible Beans*

	SITE OF ACTION	CROP TOLERANCE**	ANNUAL BROADLEAVES									ANNUAL GRASSES								PERENNIALS				
			COCKLEBUR	JIMSONWEED	LAMBSQUARTERS	NIGHTSHADE (E. BLACK)	PIGWEED	RAGWEED (COMMON)	SMARTWEED	VELVETLEAF	WILD MUSTARD	BARNYARDGRASS	CRABGRASS	GIANT FOXTAIL	GREEN FOXTAIL	YELLOW FOXTAIL	FALL PANICUM	WITCHGRASS	SANDBUR	BINDWEED (FIELD)	BINDWEED (HEDGE)	CANADA THISTLE	QUACKGRASS	YELLOW NUTSEDGE
Preplant Incorporated																								
DUAL MAGNUM/PARALLEL	15	2	N	N	P	F	**G**	P	P	N	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	F	N	N	N	N	**G**
EPTAM	8	2	P	P	**G**	F	F	F	F	F	F	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**G**	N	N	N	F	F
OUTLOOK	15	3[a]	N	N	P	**G**	**G**	P	P	N	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	P	N	N	N	N	F
PROWL H_2O/PROWL	3	1	N	N	**G**	P	F	P	P	F	P	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**G**	N	N	N	N	N
PURSUIT	2	3	F	F	P	**E**	**E**	P	F	F	**G**	P	P	F	F	F	P	P	P	N	N	N	N	F
SONALAN	3	1	N	N	**G**	F	**G**	P	P	N	P	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**G**	N	N	N	N	N
TRIFLURALIN	3	1	N	N	**G**	N	**G**	N	P	N	P	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**G**	N	N	N	N	N
Preemergence																								
DUAL MAGNUM/PARALLEL	15	2	N	N	P	F	**G**	P	P	N	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	F	N	N	N	N	F
OUTLOOK	15	3[a]	N	N	P	**G**	**G**	P	P	N	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	P	N	N	N	N	F
PERMIT/SANDEA	2	3	F	F	F	P	**E**	**G**	P	**G**	**E**	N	N	N	N	N	N	N	N	N	N	N	N	F
PURSUIT	2	3	P	P	P	**E**	**E**	P	F	P	**G**	P	P	F	F	F	P	P	P	N	N	P	N	F
REFLEX	14	2	P	P	**G**	**E**	**E**	**G**	**G**	P	**E**	N	N	N	N	N	N	N	N	N	N	N	N	N
SEQUENCE[b]	9/15	2	N	N	P	F	**G**	P	P	N	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	F	N	N	N	N	F
Postemergence																								
ASSURE II/TARGA	1	1	N	N	N	N	N	N	N	N	N	**G**	**G**	**E**	**E**	**G**	**E**	**E**	**E**	N	N	N	**E**	N
BASAGRAN/BROADLOOM[c]	6	2	**E**	**G**	F	P	P	F	**E**	**G**	**E**	N	N	N	N	N	N	N	N	N	N	**G**	N	**G**
FUSILADE DX	1	1	N	N	N	N	N	N	N	N	N	**E**	**G**	**E**	**E**	**E**	**E**	**E**	**E**	N	N	N	**G**	N
PERMIT	2	3	**E**	**G**	N	P	**E**	**G**	F	**G**	**E**	N	N	N	N	N	N	N	N	P	P	P	N	**E**
POAST	1	1	N	N	N	N	N	N	N	N	N	**E**	**G**	**E**	**E**	**E**	**E**	**E**	**E**	N	N	N	F	N
PURSUIT[d]	2	3	F	P	P	**E**	**E**	P	F	F	**E**	P	P	F	P	P	P	P	P	N	N	P	N	F
PURSUIT[d] + BASAGRAN	2/6	2	**E**	**G**	F	**E**	**E**	F	**G**	**G**	**E**	P	P	F	P	P	P	P	P	N	N	**G**	N	**G**
RAPTOR[d]	2	3	F	F	F	**E**	**E**	P	F	**G**	**E**	F	P	F	P	P	P	P	P	N	N	P	N	P
RAPTOR[d] + BASAGRAN 8 oz (4L) or 6.4 oz (5L)	2/6	2	**G**	F	F/**G**	**E**	**E**	F	**G**	**G**	**E**	F	P	F	P	P	P	P	P	N	N	F	N	F
RAPTOR[de] + BASAGRAN 16 oz (4L) or 12.8 oz (5L)	2/6	2	**E**	**G**	**G**	**E**	**E**	F	**E**	**G**	**E**	P	P	F	P	P	P	P	P	N	N	**G**	N	F
REFLEX	14	2	P	F	P	**G**	**G**	**E**	P	P	**E**	N	N	N	N	N	N	N	N	N	N	N	N	N
REFLEX + BASAGRAN	6/14	2	**E**	**G**	F/**G**	**G**	**G**	**E**	**E**	**G**	**E**	N	N	N	N	N	N	N	N	N	N	F	N	**G**
REFLEX + RAPTOR[e]	2/14	3	F	F	F	**E**	**E**	**E**	F	**G**	**E**	F	P	F	P	P	P	N	N	N	N	P	N	P
SELECT/SELECT MAX/ARROW	1	1	N	N	N	N	N	N	N	N	N	**E**	**G**	**E**	**E**	**E**	**E**	**E**	**E**	N	N	N	**G**	N
VARISTO	2/6	2	**E**	**G**	**G**	**E**	**E**	F	**E**	**G**	**E**	P	P	F	P	P	P	P	P	N	N	**G**	N	F

Herbicide Site of Action: The site of action key is located on pages 15-16.

Herbicide Effectiveness: P = Poor; F = Fair; **G** = Good; **E** = Excellent; N = None

*The above ratings are a relative comparison of herbicide effectiveness. Weather conditions greatly influence the herbicide's effectiveness, and weed control may be better under favorable conditions or poorer under unfavorable conditions.

** Crop Tolerance: 1 = Minimal risk of crop injury; 2 = Crop injury can occur under certain conditions (soil applied — cold, wet; foliar applied — hot, humid); 3 = Severe crop injury can occur. Follow precautions under Remarks and Limitations and on the label; 4 = Risk of severe crop injury is high.

[a] Crop tolerance for navy and black beans = 3. For other bean classes, crop tolerance = 2. Preplant incorporation will increase tolerance of navy and black beans to *Outlook*.

[b] Sequence is a premixture of *Dual Magnum* and glyphosate and should be used to control existing vegetation prior to planting dry beans. See Remarks and Limitations section.

[c] Control of **hairy nightshade** is good.

[d] Control of **hairy nightshade** with *Pursuit* and *Raptor* is excellent.

[e] **Common lambsquarters** will be controlled with this tank mixture ***if*** the weeds are less than 2 inches tall and ***not*** under drought stress.

TABLE 5B – Dry Edible Bean Herbicides – Remarks and Limitations

Dry Edible Beans — Preplant Incorporated Only

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
Annual grasses	EPTC *(Eptam)*	2.25	1.25 qt 7EC	• **Apply preplant incorporated only**. • Refer to Table 5A for weed control and crop tolerance ratings. • Incorporate immediately after application. • *Eptam* suppresses common ragweed and wild mustard. • ***Prowl* (pendimethalin)**, ***trifluralin***, or ***Sonalan*** should be **tank mixed** with ***Eptam*** for additional broadleaf control, including lambsquarters. • *Pursuit* (2 oz) can be added to tank mixes with *Prowl*, *trifluralin*, or *Sonalan* for nightshade control. • *Pursuit* (2 oz) may also be applied preemergence after preplant incorporated applications of *Eptam* tank mixed with *Prowl, trifluralin*, or *Sonalan*. See remarks for *Pursuit*. • A postemergence application of *Basagran, Pursuit* or *Raptor* may be necessary for additional broadleaf control. • DO NOT use on adzuki beans. • Refer to label and Table 12 for crop rotation restrictions.
Annual grasses **Annual broadleaves**	pendimethalin *(Prowl)* OR *(Prowl H_2O)*	0.75	1.8 pt 3.3EC OR 1.6 pt 3.8CS	• **Apply preplant incorporated only**. • Refer to Table 5A for weed control and crop tolerance ratings. • Incorporate immediately after application. • *Prowl* provides better velvetleaf control than *trifluralin* or *Sonalan*. • ***Prowl*** should be **tank mixed** with ***Eptam***. Other measures may need to be taken for additional broadleaf control. • Refer to label and Table 12 for crop rotation restrictions.
	ethalfluralin (Sonalan)	0.75	2 pt 3EC	• **Apply preplant incorporated only.** • Refer to Table 5A for weed control and crop tolerance ratings. • Incorporate immediately after application. • ***Sonalan*** should be **tank mixed** with ***Eptam***. Other measures may need to be taken for additional broadleaf control. • Refer to label and Table 12 for crop rotation restrictions.
	trifluralin *(many)*	0.5	1 pt 4EC	• **Apply preplant incorporated only.** • Refer to Table 5A for weed control and crop tolerance ratings. • Incorporate immediately after application. • *Trifluralin* provides better pigweed control than *Prowl* or *Sonalan*. • ***Trifluralin*** should be **tank mixed** with ***Eptam***. Other measures may need to be taken for additional broadleaf control. • Refer to label and Table 12 for crop rotation restrictions.

Dry Edible Beans — Soil Applied

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
Annual grasses	s-metolachlor *(Dual Magnum, EverpreX)* OR *(Dual II Magnum, Cinch)*	1.27	1.33 pt 7.62EC OR 1.33 pt 7.64EC	• **May be applied preplant incorporated or preemergence.** • Refer to Table 5A for weed control and crop tolerance ratings. • PREPLANT INCORPORATED *Dual Magnum* minimizes the danger of bean injury. • DO NOT apply if soil is cracking and beans are in the crook stage. • Reduce *Dual Magnum* rate to 1 pt/A on coarse-textured soils with low organic matter. • Preemergence applications require rainfall for incorporation. Rotary hoe if no rainfall occurs within 7 days. • *Dual Magnum* provides better yellow nutsedge control than *Outlook*. • *Prowl, trifluralin* or *Sonalan* can be tank mixed preplant incorporated for lambsquarters control. • *Pursuit* (2 oz) can be tank mixed for nightshade and additional broadleaf control. • A postemergence application of *Basagran, Pursuit* or *Raptor* may be necessary for additional broadleaf control. • DO NOT apply *Dual Magnum* within 60 days of harvest. • DO NOT use on adzuki beans. • Refer to label and Table 12 for crop rotation restrictions.
	dimethenamid-P *(Outlook)*	0.66	14 oz 6L	• **May be applied preplant incorporated or preemergence.** • Refer to Table 5A for weed control and crop tolerance ratings. • PREPLANT INCORPORATED Outlook minimizes the danger of bean injury. • DO NOT apply if soil is cracking and beans are in the crook stage. • Reduce *Outlook* rate to 12 oz/A on coarse-textured soils with low organic matter. • Navy and black beans are more sensitive to *Outook* applications than to *Dual Magnum*. • Preemergence applications require rainfall for incorporation. Rotary hoe if no rainfall occurs within 7 days. • *Outlook* provides better pigweed and nightshade control than *Dual Magnum*. • *Prowl, trifluralin,* or *Sonalan* can be tank mixed preplant incorporated for lambsquarters control. • *Pursuit* (2 oz) can be tank mixed for nightshade and additional broadleaf control. • A postemergence application of *Basagran, Pursuit,* or *Raptor* may be necessary for additional broadleaf control. • DO NOT apply *Outlook* within 70 days of harvest. • DO NOT use on adzuki beans. • Refer to label and Table 12 for crop rotation restrictions.

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Dry Edible Beans — Soil Applied *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
(continued)				
Annual grasses	metolachlor *(Parallel PCS)*	1.3	1.33 pt 8EC	• **May be applied preplant incorporated or preemergence.** • *Parallel PCS* is a mix of the R and S-isomers of metolachlor. Limited research has shown that 1.33 pt/A of these products provide similar activity to s-metolachlor products at 1.33 pt/A. However, *Parallel PCS* may not provide the consistency, length of control or performance on more difficult to control weeds. Rates would need to be increased to 2.0 pt/A to provide the same amount of s-metolachlor (the more active isomer) in the 1.33 pt/A rate of *Dual Magnum/ Dual II Magnum/Cinch* (s-metolachlor). • Refer to Table 5A for weed control and crop tolerance ratings. • See remarks and limitations for *Dual Magnum*. • DO NOT use on adzuki beans. • Refer to label and Table 12 for crop rotation restrictions.
	glyphosate + s-metolachlor *(Sequence)* + ammonium sulfate	1.64	3 pt 2.25L + 17 lb/100 gal	• **May be applied preplant or preemergence.** • Sequence contains 0.9 lb a.e./A of glyphosate and 1.2 pt/A of *Dual Magnum*. • *Sequence* is best used to control existing vegetation prior to planting no-till dry beans with the residual control of *Dual Magnum*. • Refer to Table 5A for residual weed control and crop tolerance ratings. • DO NOT apply to emerged dry bean – severe injury will occur. • DO NOT apply more than 3.5 pt/A on coarse textured soils or 4 pt/A on medium and fine textured soils. • Apply only one application per crop year. • Refer to label and Table 12 for crop rotation restrictions.
Annual broadleaves	halosulfuron *(Permit/Sandea)*	0.023	0.67 oz 75DG	• **May be applied preplant incorporated or preemergence.** • Refer to Table 5A for weed control and crop tolerance ratings. • Reduce the rate of *Permit/Sandea* to 0.5 oz/A on lighter textured soils with low organic matter. • *Permit/Sandea* can cause injury under cool and wet growing conditions. • Delayed maturity may result from applications of *Permit/ Sandea*. • Dry bean varieties and classes vary in their tolerance to *Permit/Sandea*. From MSU research, CAUTION should be taken when applying *Permit/Sandea* to kidney and black beans. • *Permit/Sandea* can be tank mixed with *Eptam* for grass and additional lambsquarters control. • *Permit/Sandea* can be tank mixed with metolachlor products or *Outlook* for annual grass control. • *Permit/Sandea* will not control ALS-resistant weed species. • DO NOT plant SUGAR BEETS within 21 months of a *Permit/ Sandea* application. • Refer to label and Table 12 for crop rotation restrictions.

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Dry Edible Beans — Soil Applied *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
(continued)				
Annual broadleaves	imazethapyr *(Pursuit)*	0.031	2 oz 2L	• **May be applied preplant incorporated or preemergence.** • Refer to Table 5A for weed control and crop tolerance ratings. • DO NOT use on sands or loamy sand soils. • DO NOT apply *Pursuit* if cold and/or wet conditions are present or predicted to occur within 1 week of application. • Delayed maturity may result from applications of *Pursuit*. DO NOT apply if planting is delayed and frost is likely to occur prior to maturity. • On heavy soils with greater than 2% organic matter and heavy weed pressure, 3 oz of *Pursuit* may be applied. • *Pursuit* can be tank mixed and applied preplant incorporated with *Eptam* plus *trifluralin*; *Prowl* or *Sonalan*; or *Dual Magnum* or *Outlook*; or preemergence with *Dual Magnum* or *Outlook*. *Pursuit* in these mixes will control eastern black nightshade. • Preemergence applications require rainfall for incorporation. Rotary hoe if no rainfall occurs within 7 days. • *Pursuit* will NOT control common ragweed. • Dry bean varieties vary in their sensitivity to *Pursuit*. Use ONLY on navy, black turtle, pinto, kidney, and cranberry beans. DO NOT use on DOMINO black or OLATHE pinto beans. • DO NOT apply within 60 days of harvest. • DO NOT use if SUGAR BEETS, CUCUMBERS, CANOLA or TOMATOES are in the rotation; requires 40 months and a soil bioassay. • Refer to label and Table 12 for crop rotation restrictions.
	fomesafen *(Reflex)*	0.25	1 pt 2L	• **May be applied preplant surface or preemergence.** • Refer to Table 5C for weed control and crop tolerance ratings. • *Reflex* will provide 4-5 weeks of control and/or suppression of broadleaf weeds. • Rainfall that splashes treated soil onto newly emerged seedlings can cause temporary crop injury. • Tank mixtures or sequential herbicide applications are needed to broaden the spectrum of weed control. • *Reflex* can be applied only in the Lower Peninsula of Michigan. • DO NOT apply *Reflex* or other fomesafen products to the same field in CONSECUTIVE years. • The maximum use rate of *Reflex* per field is 1 pint per acre. • Refer to Table 12 for crop rotation restrictions.

Dry Edible Beans — Postemergence

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
Grasses	quizalofop-P-ethyl *(Assure II/Targa)* + crop oil concentrate OR surfactant	0.044	7 oz 0.88L + 1% OR 0.25%	• Refer to Table 5A for weed control and crop tolerance ratings. • Treat actively growing grasses (annual grasses up to 4 inches). • DO NOT apply to grasses under stress — poor weed control will result. • DO NOT cultivate within 5 days prior to and 7 days following application. • Allow 30 days between *Assure II/Targa* application and dry bean harvest. • *Assure II/Targa* can be tank mixed with *Basagran* for foxtails and barnyardgrass. Increase the *Assure II/Targa* rate by 2 oz. • Tank mixes with *Pursuit* and *Raptor* are not recommended — grass antagonism will occur. • *Assure II/Targa* (10 oz/A) plus crop oil concentrate (1% v/v) or nonionic surfactant (0.25% v/v) will control quackgrass 6-10 inches tall. A sequential application of 7 oz/A may be needed 14-21 days later. • Refer to label and Table 12 for crop rotation restrictions.
	fluazifop-P-butyl *(Fusilade DX)* + crop oil concentrate	0.188	12 oz 2L + 1%	• Refer to Table 5A for weed control and crop tolerance ratings. • Apply 6 oz/A of *Fusilade DX* to control volunteer corn. • Allow 60 days between *Fusilade DX* application and dry bean harvest. • Two applications 7-14 days apart are usually needed for control of perennial grasses. • Tank mixes with *Pursuit* and *Raptor* are not recommended – grass antagonism will occur. • DO NOT apply more than 48 oz/A of *Fusilade DX* per season. • Refer to label and Table 12 for crop rotation restrictions.
	sethoxydim *(Poast)* + crop oil concentrate + ammonium sulfate	0.19	1 pt 1.5SC + 1 qt + 2.5 lb	• Refer to Table 5A for weed control and crop tolerance ratings. • Reduced rates of *Poast* (12 oz/A) may be used when barnyardgrass, green and giant foxtail, and fall panicum l are ess than 4 inches tall and the target species. • DO NOT apply to grasses under stress — poor weed control will result. • DO NOT cultivate within 5 days prior to and 7 days following application. • Allow 30 days between *Poast* application and dry bean harvest. • *Poast* is generally less effective than other postemergence grass herbicides for perennial grass control. • Tank mixes with *Pursuit* and *Raptor* are not recommended— grass antagonism will occur. • Refer to label and Table 12 for crop rotation restrictions.

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Dry Edible Beans — Postemergence *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
(continued)				
Grasses	clethodim *(Select/Arrow)* + crop oil concentrate OR *(Select Max)* + surfactant + ammonium sulfate	0.094 0.068 	6 oz 2EC + 1% OR 9 oz 0.97EC + 0.25% + 2.5 lb	• Refer to Table 5A for weed control and crop tolerance ratings. • Reduced rates of *Select/Arrow* (4-5 oz/A) or *Select Max* (6-8 oz/A) may be used when some grass species are small. • The addition of ammonium sulfate at 2.5 to 4 lb/A has been shown to improve control of difficult to control weeds, e.g., quackgrass, rhizome Johnsongrass, volunteer cereals, and volunteer corn. • DO NOT apply to grasses under stress — poor weed control will result. • DO NOT cultivate within 7 days prior to and 7 days following application. • Allow 30 days between application and dry bean harvest. • *Select/Arrow* or *Select Max* can be tank mixed with *Basagran*. Increase the *Select/Arrow* rate to 8-10 oz/A and the *Select Max* rate to 12 oz/A and apply with crop oil concentrate (1% v/v). • Tank mixes with *Pursuit* and *Raptor* are not recommended—grass antagonism will occur. • *Select/Arrow* (8-16 oz/A) plus crop oil concentrate (1% v/v) plus ammonium sulfate (2.5 lb/A) will control quackgrass 4-12 inches tall. A sequential application of 8 oz/A may be needed 14-21 days later. Sequential applications of *Select Max* (12 + 12 oz/A) are needed to control 4 to 12 inch quackgrass. • Refer to label and Table 12 for crop rotation restrictions.
Annual broadleaves	bentazon *(Basagran/Broadloom)* OR *Basagran 5L* + crop oil concentrate	0.75	1.5 pt 4L OR 1.2 pt 5L + 1 qt	• Refer to Table 5A for weed control and crop tolerance ratings. • Most effective on small weeds. Check dry bean label for specific rate and proper weed growth stage. • Beans MUST HAVE one fully expanded trifoliate before application. • Use a minimum of 20 gal. water/A for adequate coverage. • DO NOT apply if dry beans are under stress from herbicide injury, cold or dry weather, or hail damage. • For improved velvetleaf control 28% liquid nitrogen (2-4 qt/A) or ammonium sulfate (2.5 lb/A) can be used INSTEAD OF crop oil concentrate. However, if common ragweed and common lambsquarters are present, a crop oil concentrate must also be included. • Split applications of 1 pt + 1 pt (4L) or 0.8 pt + 0.8 pt (5L) plus crop oil concentrate (1 pt + 1 pt) can be used for more consistent common ragweed and lambsquarters control. Make the first application when weeds are less than 1 inch tall, and make second application 10-14 days later. • For CANADA THISTLE and YELLOW NUTSEDGE control, apply sequential applications of 1.5 pt + 1.5 pt (4L) or 1.2 pt + 1.2 pt (5L) plus crop oil concentrate (1 qt + 1 qt) when Canada thistle is 6-8 inches tall and yellow nutsedge is 4-6 inches. Make second application 7-10 days later. • Allow 30 days between application and dry bean harvest. • DO NOT use on adzuki beans. • Refer to label and Table 12 for crop rotation restrictions.

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Dry Edible Beans — Postemergence *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
(continued)				
Annual broadleaves	halosulfuron *(Permit)* + surfactant	0.023	0.67 oz 75WG + 0.25%	• Refer to Table 5A for weed control and crop tolerance ratings. • Most effective on small weeds (less than 2 inches). • Apply when beans have 1-3 trifoliate leaves. • DO NOT apply if dry beans have begun to flower. • *Permit* can be tank-mixed with other herbicides for additional broadleaf and grass control. • Dry bean varieties and classes vary in their tolerance to *Permit*. From MSU research, CAUTION should be taken when applying to kidney and black beans. Under adverse conditions maturity of the treated crop can be delayed which can affect harvest date, yield, and quality. • DO NOT use on adzuki beans. • DO NOT plant SUGARBEETS within 21 months of *Permit* application. • Refer to Table 12 for crop rotation restrictions.
	imazethapyr *(Pursuit)* + surfactant	0.031	2 oz 2L + 0.25%	• Refer to Table 5A for weed control and crop tolerance ratings. • Most effective on small weeds (less than 2 inches). • Beans MUST HAVE one fully expanded trifoliate before application. • DO NOT apply if dry beans have begun to flower. • Apply *Pursuit* with non-ionic surfactant (0.25% v/v). • DO NOT add 28% liquid nitrogen (2.5% v/v) or ammonium sulfate (2.5 lb/A) unless at least 8 oz of *Basagran* 4L is added to "safen" this application. • Increase the rate of *Basagran* 4L to 16 fl oz (4L) or 12.8 fl oz (5L) when tank mixed with *Pursuit* to control common cocklebur and jimsonweed. • Delayed maturity may result from applications of *Pursuit*. DO NOT apply if planting is delayed and frost is likely to occur prior to maturity. • DO NOT tank mix with postemergence grass herbicides — grass antagonism will occur. • Dry bean varieties vary in their sensitivity to *Pursuit*. Use ONLY on navy, black turtle, pinto, kidney, and cranberry beans. DO NOT use on DOMINO black or OLATHE pinto beans. • DO NOT apply within 60 days of harvest. • DO NOT use if sugar beets, cucumbers, canola or tomatoes are in the rotation; requires 40 months and a soil bioassay. • DO NOT use on adzuki beans. • Refer to label and Table 12 for crop rotation restrictions.

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Dry Edible Beans — Postemergence *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
(continued)				
Annual broadleaves	imazamox *(Raptor)* + bentazon *(Basagran)* + crop oil concentrate + ammonium sulfate	0.032 0.25	4 oz 1L + 8 oz 4L OR 6.4 oz 5L + 1% + 2.5 lb	• Refer to Table 5A for weed control and crop tolerance ratings. • Most effective on small weeds (less than 2 inches). • Beans MUST HAVE one fully expanded trifoliate before application. • DO NOT apply if dry beans have begun to flower. • DO NOT apply if planting is delayed and frost is likely to occur prior to maturity. • Apply *Raptor* with crop oil concentrate (1% v/v) or a non-ionic surfactant (0.25% v/v). • At least 8 fl oz of *Basagran* 4L or 6.4 fl oz (5L) **must** be tank mixed with *Raptor*, if ammonium sulfate (12-15 lb/100 gal) or 28% liquid nitrogen (2.5% v/v) are added. *Basagran* "safens" this application. • Increase the rate of *Basagran* to the 16 fl oz (4L) or 12.8 fl oz (5L) when tank mixed with *Raptor* to control common cocklebur and jimsonweed, and to provide good control of common lambsquarters (less than 2 inch tall). • DO NOT tank mix with postemergence grass herbicides — grass antagonism will occur. • DO NOT apply within 60 days of harvest. • DO NOT use the combination of *Raptor* + *Basagran* on adzuki beans. *Basagran* causes significant injury to adzuki beans. • Refer to label and Table 12 for crop rotation restrictions.
	fomesafen *(Reflex)* + surfactant	0.25	1 pt 2L + 0.25%	• Refer to Table 5A for weed control and crop tolerance ratings. • Most effective on small weeds; common ragweed 4-inches or less and eastern black nightshade 2-inches or less. • Common ragweed less than 4-inches will be controlled with 0.5 pt/A of *Reflex*. • Beans MUST HAVE one fully expanded trifoliate before application. • A non-ionic surfactant at 0.25-0.5% v/v or a crop oil concentrate at 0.5-1.0% v/v must be included for effective control. • *Reflex* can be tank-mixed with *Basagran*, *Raptor*, or *Pursuit*. Include a COC when tank-mixing *Reflex* + *Basagran*. ONLY include a non-ionic surfactant when tank-mixing with *Raptor* or *Pursuit*. DO NOT add AMS or 28%N. • *Reflex* can be applied only in the Lower Peninsula of Michigan. • DO NOT apply *Reflex* or other fomesafen containing products to the same field in CONSECUTIVE years. • DO NOT apply within 45 days of harvest. • Refer to Table 12 for crop rotation restrictions.
	basagran + imazamox (*Varisto*) + crop oil concentrate + ammonium sulfate	0.68	21 oz 4.18L + 1% + 2.5 lb	• Refer to Table 5A for weed control and crop tolerance ratings. • *Varisto* at 21 fl oz/A is equivalent to 21 fl oz (4L) or 16.8 fl oz (5L) of *Basagran* and 4 fl oz/A of *Raptor*. • Most effective on small weeds (less than 2 inches). • Beans must have one fully expanded trifoliate before application. • DO NOT apply if dry beans have begun to flower. • DO NOT tank-mix with postemergence grass herbicides – grass antagonism will occur. • DO NOT apply within 30 days of harvest. • DO NOT use on adzuki beans. • Refer to label and Table 12 for crop rotation restrictions.

Table 5C – Preharvest Treatments in Dry Edible Beans

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
Preharvest	glyphosate *(many)* + ammonium sulfate	0.75 lb a.e.	See Table 10 + 17 lb/100gal	• Glyphosate should ONLY be used to control weeds that hinder harvest. • Not all glyphosate products are labeled for **Preharvest** application in dry edible beans. Consult product labels for legal applications. Roundup branded products, *Duramax, Durango DMA, Touchdown Total* and *Traxion* are some glyphosate products that are currently labeled. • ***DO NOT*** use glyphosate for **vine desiccation** — residues of glyphosate have been found in harvested beans if applications are made too early. • Glyphosate should be applied when beans are in the ***hard dough stage*** **(30% moisture or less)**. • Some buyers will not purchase beans treated with glyphosate, consult your buyer prior to using glyphosate as a preharvest herbicide treatment. • Glyphosate applications should be made at least 7 days before harvest. • ONLY one application should be made per year. • DO NOT apply glyphosate to beans grown for seed. • DO NOT feed treated vines and hay from these crops to livestock.
	paraquat *(Gramoxone SL 2.0)* + surfactant	0.3-0.5	1.2–2 pt 2SL + 0.25%	• ***Gramoxone*** **is a restricted-use pesticide.** Certified applicators are now required to complete a paraquat specific training prior to use of *Gramoxone.* The paraquat training course can be found online at: https://www.epa.gov/pesticide-worker-safety/paraquat-dichloride-training-certified-applicators. • Apply when crop is mature, at least 80% of the pods are yellowing and mostly ripe and no more than 40% (bush-type beans) or 30% (vine-type beans) of the leaves are still green. • Always add a non-ionic surfactant at 0.25% v/v or a crop oil concentrate at 1% v/v • Apply by air in 5 gal water/A or by ground in 20-40 gal of water/A. • If growth is lush and vigorous, make either a single application of the higher rate of *Gramoxone SL 2.0*; or split applications at the lower rates. Split applications may improve vine coverage. DO NOT exceed 2.0 pt/A of *Gramoxone SL 2.0*. • Do not harvest within 7 days of application.
	paraquat *(Parazone)* + surfactant	0.5	1.33 pt 3SL + 0.25%	• ***Parazone*** **is a restricted-use pesticide.** Certified applicators are now required to complete a paraquat specific training prior to use of *Parazone.* The paraquat training course can be found online at: https://www.epa.gov/pesticide-worker-safety/paraquat-dichloride-training-certified-applicators. • *Parazone* contains the same active ingredient as *Gramoxone SL 2.0* (paraquat), but is at a different concentration. • See the Remarks and Limitation section for *Gramoxone SL 2.0*.

(Continued on next page)

Preharvest Treatments in Dry Edible Beans *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
(continued)				
Preharvest	saflufenacil *(Sharpen)* + methylated seed oil + ammonium sulfate	0.023	1 oz 2.85L + 1% + 17 lb/100 gal	• Apply when crop is mature – at least 80% of the pods are yellowing and mostly ripe and no more than 40% (bush-type beans) or 30% (vine-type) beans of the leaves are still green. • *Sharpen* can be applied at rates up to 2 oz/A. • Dry beans can be harvested 2 days after application. However, it generally takes 7 days to reach maximum desiccation activity. • *Sharpen* is an effective desiccant. • DO NOT apply to beans grown for seed. • DO NOT graze or feed desiccation-treated hay or straw to livestock. • Refer to label and Table 12 for crop rotation restrictions. DO NOT include time in the rotation interval when the ground is frozen.
	flumioxazin *(Valor)* OR *(Valor EZ)* + methylated seed oil	0.05	1.5 oz 51WG OR 1.5 oz 4L + 1 qt	• Apply when crop is mature – at least 80% of the pods are yellowing and mostly ripe and no more than 40% (bush-type beans) or 30% (vine-type beans) of the leaves are still green. • *Valor/Valor EZ* can be applied at rates up to 2 oz/A. • Dry beans can be harvested 5 days after *Valor* application. However, it generally takes 7 to 14 days to reach maximum desiccation activity. • Dry bean desiccation is similar to that from *Gramoxone* and glyphosate; however, the spectrum of weed control is not as broad. • *Valor* provides residual activity that may reduce winter annual growth. • Follow sprayer clean-up instructions — residues of *Valor* can be trapped in poly-tanks and hoses if not adequately cleaned. • Crop rotation restrictions are dependent on rainfall, *Valor* use rate and tillage. • Rotation restrictions for 2 oz or less of *Valor/Valor EZ* are 1 month with 1 inch of rain for corn and winter wheat. Dry bean and barley may be planted after 3 months, and alfalfa, oats and sugar beets may be planted after 4 months if the ground is tilled prior to planting or 8 months if no tillage is performed. Note: In Michigan research trials, planting sugar beet no-till the spring following a *Valor* preharvest treatment resulted in major sugar beet stand reduction. Tillage reduced the effect of *Valor* on sugar beet; however, slight injury may occur on sandier soils. • Refer to label and Table 12 for crop rotation restrictions.
	carfentrazone *(Aim)* + methylated seed oil	0.03	2 oz 2EC + 1% v/v	• Apply when crop is mature – at least 80% of the pods are yellowing and most ripe and no more than 40% (bush-type beans) or 30% (vine-type beans) of the leaves are still green. • *Aim* alone is not as effective as *Sharpen*, glyphosate, *Gramoxone*, or *Valor* for dry bean desiccation. • Tank mixtures with *Gramoxone* or glyphosate will improve dry bean desiccation and is needed to improve the spectrum of weed desiccation. • Thorough spray coverage is required – sequential applications may be needed. • The preharvest interval is 0 days for *Aim* alone.

Michigan Dry Edible Bean Production Research Advisory Board

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