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Identification of Improved Dry Bean Varieties, Maturities, and Integrated Weed Management Systems: Managing Production for a Evolving Market Place

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In 2021 the Michigan Bean Commission was awarded a grant from the Michigan Department of Agriculture and Rural Development through the USDA Specialty Crop Block Competitive Grant Program. This project was titled: '***Identification of Improved Dry Bean Varieties, Maturities, and Integrated Weed Management Systems: Managing Production for a Evolving Market Place'.*** This work addresses the need to improve management strategies for dry beans in Michigan. The outcome will be the improvement of sustainable management practices for dry beans in an ever- changing marketplace. Objectives of this project were to: **(1)** Development of dry bean cultivars and breeding lines that are resilient to environmental stress and mature uniformly across diverse production regions in Michigan. **(2)** Improve weed control strategies to improve weed control in Michigan dry beans with increasingly difficult environmental conditions and the development of herbicide resistant weed species. (**3)** Validate current recommendations for harvest-aid applications with a focus on navy beans to ensure delivery of maximum first pass quality. (**4)** Implementation of grower educational activities to communicate intervention strategies and economic options for improved production practices for premium quality Michigan dry beans.

Season Summary: Planting conditions for the 2022 dry bean crop were very good. The state of Michigan received average to slightly below average rainfall in the months leading up to dry bean planting in June, this resulted in average to slightly lower than average levels of soil moisture at planting compared to a 5-year average. However, moisture was sufficient for planting and germination of the 2022 dry bean crop. Into late June and July significant rainfall was scarce and wind damage occurred at moderate levels across the production region due to excess soil movement from wind erosion. As the dry bean crop progressed into July and August timely light rains were received that were very conducive for pod set and fill. Generalized across locations, later planting dates appear to have out performed earlier planting dates in 2022. Limiting factors through midseason included lack of soil moisture and periodic stretches of very hot weather that caused blossom abortion on the uppermost branches of some dry bean plants. This hot weather brought on an early harvest starting in late August and nearly complete by October 10. In general, dry bean yields were average to above average with excellent quality. In particular, small red bean color in 2022 was the best in recent memory.

We would like to thank all cooperators that hosted trials in 2022. Without their assistance, this research would not be possible.

Thank you,

Scott Bales & Joe Cramer

Introduction

In 2022, Michigan State University researchers and Michigan dry bean producers tested 161 lines from 12 market classes of dry beans. The trial plots (Table 1) were placed in six locations across five Michigan counties: Bay, Huron, Montcalm, Sanilac, and Tuscola (two sites).

Small- and medium-seeded beans were tested in Bay, Huron, Sanilac, and Tuscola counties. Large-seeded beans were tested in Montcalm County and at the Saginaw Valley Research and Extension Center (SVREC) in Tuscola County.

This report summarizes the results of the trials including processing quality. Please contact Scott Bales (phone 989-262-8550, ext. 2; email balessco@msu.edu) with questions about the 2022 performance trials and suggestions for the 2023 trials.

Table 1. 2022 research trial conditions: The locations, grower co-operators, planting dates, nitrogen application rates and methods, total accumulated growing degree days (GDD), and total precipitation.

County	Co-operator	Planting Date	Nitrogen Rate *(Lbs./A)*	Nitrogen Application Method	Total GDD [a]	Total Precipitation *(Inches)*
Bay	Schindler Farms	June 15	50	Broadcast	1,847	11.37”
Huron	Richmond Brothers	June 8	50	2x2	1,868	5.37”
Montcalm	Rader Farms	June 10	60	Broadcast + 2x2	1,935	13.50” + irrigation
Sanilac	Stoutenburg Farms	June 3	50	Broadcast + 2x2	1,998	8.00”
Tuscola (kidney beans)	Saginaw Valley Research and Extension Center	May 31	40	Broadcast	1,960	7.57”
Tuscola (small & medium seed)	Rayl Farms	June 2	50	2x2	2,108	9.52”

Note. Weather data was retrieved from on-site weather systems reporting to LOCOMOS (Low-Cost Monitoring System) stations. All weather data is from the day of planting to harvest.

[a]Growing degree days (GDD) were calculated using the following equation: $([\mathrm{MAX} + \mathrm{MIN}] \div 2) - 50 = \mathrm{GDD}$

Field Trial Methods

Dry beans were seeded in four-row plots that measured 6.6′ wide by 20′ long, with 20″ rows. Each entry was replicated four times. All trial plots were designed as randomized complete blocks (RCB). (RCB is a standard agricultural trial design in which entries are randomly assigned to groups or blocks, and the blocks are randomly repeated. The goal of the replication is to control for variables that might affect an entry’s yield, such as soil nutrient levels, pest loads, and variability in soil textures.)

Trials received industry standard seed treatments, fertilization, and weed control applications at labeled rates. White mold fungicides were not applied to any location. The absence of fungicide allowed the evaluation of each entry’s natural tolerance for or avoidance of white mold.

Yield data was obtained by direct harvest for small- and medium-seeded beans. Large-seeded beans were pulled by a two-row Pickett bean puller and then mechanically threshed to prevent harvest loss. Following harvest, samples were cleaned, weighed, and moisture tested.

Table 2. Soil test information from the six 2022 performance trial locations, including the percentage of organic matter, soil type, and soil pH. All macro- and micronutrients were sufficient for dry bean production.

Location	Percentage of Organic Matter	Soil Type	Soil pH
Bay	2.3	Loam	7.3
Huron	2.2	Loam	7.6
Montcalm	1.6	Loamy Sand	6.3
Sanilac	3.5	Loam	7.2
Tuscola (Kidney beans)	2.5	Clay Loam	7.7
Tuscola (Small and medium seed)	2.5	Sandy Loam	7.1

Yield Results

Tables 5 through 14 provide agronomic information such as plant maturity and white mold tolerance. Plant maturity was rated visually in days after planting (DAP) for all locations. The percentage of white mold infection on each replication was calculated in Bay, Tuscola, and Montcalm counties:

$$\textbf{(number of infected plants} \div \textbf{total plants per stand)} \times \textbf{100 = percentage of infection}$$

The tables also present each entry's yield results in pounds per acre (Lbs./A) adjusted to 18% moisture.

The combined average yield for each entry across all sites in 2022 is also included. (**Note:** If an entry was grown under different production systems [irrigated versus dry land] at different sites, the combined yield was not calculated.) When possible, two- and three-year average yields were also calculated across locations. For example, the three-year average yield of a navy bean entry (Table 3) includes data from 2020, 2021, and 2022 at four locations per year (12 site-years).

The last three rows of the agronomic and yield results tables list the trial average (mean), least significant difference (LSD), and coefficient of variation (CV), respectively, for the data in each column.

The entry with the **highest** value in each yield column is followed by two asterisks (**). Any yields listed in the same column that are not significantly different from the highest yield are noted with one asterisk. Conversely, the entry with the **lowest** white mold infection percentage is also noted with two asterisks, and any entries in that column that are not significantly different from the lowest infection percentage are marked with one asterisk. This means that if two entries in the same column are followed by either one or two asterisks, the difference in values between the entries is not statistically significant.

Canning Methods

All 161 lines tested were sampled for canning quality. For Mesoamerican germplasm (black, navy, s. red, etc) samples were taken from Bay and Huron Trial locations, Andean germplasm was sampled from only the Montcalm Trial location, historically SVREC would be used as well, but 2022 seed quality from this location was not representative of the lines tested for processing quality. Samples were processed utilizing the following methods: Each can was filled with 100 grams of dry matter for all mesoamerican market classes. Andean beans were filled to 90 grams of dry matter per can. Moisture levels prior to soaking ranged from 11.6-18.2% averaging at 15.5% across all cultivars tested. Following subsampling dry beans were transferred to the Food Processing and Innovation Center (FPIC) an MSU facility in Okemos, MI. At FPIC two days of sample processing took place in 2023. Dry beans were soaked and blanched by market class according to the protocol in Table 3. Water for soaking included 100ppm of CaCl2 for Mesoamerican beans and 125ppm of CaCl2 for Andean beans. Immediately following blanching samples were transferred to individually identifiable cans (size 307x407) and filled with 200ºF brine. Brine is a mixture of tap water, 1.5% sucrose (sugar), 1.2% sodium chloride (salt), and 100ppm of CaCl2. Colored beans had the additional component of disodium EDTA added at a ratio of 0.02%.

Cans are then seamed and individually inspected to ensure seam quality prior to thermal processing. Cans were loaded in 552 can batches and transferred to an 'Allpax' retort. Thermal processing parameters were set for a 19 minute cook cycle at 250ºF with one rotation during cool down. Following cool down samples were stored for approximately 4 weeks prior to opening and evaluations to allow for equilibration.

Table 3. Dry Bean Brine, Soaking, Blanching and Thermal Processing by market class

Class	Brine				Rehydration		Thermal Processing
	Salt	Sugar	$CaCl_2$	EDTA	Hot Soak	Blanch	
Navy	1.2%	1.5%	100 ppm	-	30 min (125ºF)	5 min (190ºF)	19min/250ºF
Black	1.2%	1.5%	100 ppm	-	-	90 sec (185ºF)	19min/250ºF
Great Northern	1.2%	1.5%	100 ppm	-	30 min (125ºF)	15 min (190ºF)	19min/250ºF
Pinto	1.2%	1.5%	100 ppm	0.02%	2 Hr. (130ºF)	5 min (190ºF)	19min/250ºF
Small Red	1.2%	1.5%	100 ppm	0.02%	30 min (125ºF)	15 min (190ºF)	19min/250ºF
Pink	1.2%	1.5%	100 ppm	0.02%	30 min (125ºF)	15 min (190ºF)	19min/250ºF
Dark Red Kidney	1.2%	1.5%	100 ppm	0.02%	2 Hr. (130ºF)	5 min (190ºF)	19min/250ºF
Light Red Kidney	1.2%	1.5%	100 ppm	0.02%	2 Hr. (130ºF)	5 min (190ºF)	19min/250ºF
White Kidney	1.2%	1.5%	100 ppm	-	30 min (125ºF)	15 min (190ºF)	19min/250ºF
Cranberry	1.2%	1.5%	100 ppm	0.02%	2 Hr. (130ºF)	5 min (190ºF)	19min/250ºF
Yellow	1.2%	1.5%	100 ppm	-	30 min (125ºF)	5 min (200ºF)	19min/250ºF

Evaluations: On February 1st 2023 a public meeting was held for the evaluation of all lines tested. Cans were opened and scored by an 88 member panel of trained evaluators. Trained evaluators scored all market classes visually on a scale from 1-5. This scoring system has been created and validated by USDA researchers located at MSU who are also involved in the training of evaluators, and the in-person evaluations that were conducted in 2023. These evaluations were performed blind in 2023 to eliminate the possibility of any inherent bias. Table 4 documents this established scoring system based on physical characteristics of the processed sample for all market classes besides black beans. Black beans were scored similarly, but color was evaluated on a 1-5 scale independently from general appearance as this is a unique trait of economic interest in black beans.

Table 4. General appearance scale used for scorning all market classes except for black beans.

Category	Score	Bean Splitting	Brine Clarity	Free Starch/Clumps	Color
Excellent Appearance	**5**	None (90% intact)	Very Clear	Very Little Starch/Clumps	Excellent color (exceeds industry standard)
Very Good Appearance	**4**	Moderately Intact (70-89% intact)	Moderately Clear	Moderately little starch/clumps	Very good color (meets industry standard)
Average Appearance	**3**	Average (60-69% intact)	Neither Clear or Cloudy	Neither Little or Much	Average Color
Poor Appearance	**2**	Moderately Broken (badly split but holding together)	Moderately Cloudy	Moderately Many/Big Starch/clumps	Poor color (a little darker or lighter than industry standard)
Unacceptable Appearance	**1**	Severe (Seeds blown apart)	Very Cloudy	Very Big Starch/Clumps	Unacceptable color (a lot darker or lighter than industry standard)

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Table 5. Navy bean agronomic, yield and canning results.

ENTRY	Maturity (DAP)	White Mold Infection (%)	Bay (Lbs./A)	Huron (Lbs./A)	Sanilac (Lbs./A)	Tuscola (Lbs./A)	1-year avg. (Lbs./A)	2-year avg. (Lbs./A)	3-year avg. (Lbs./A)	Bay Co. Canning Score (1-5)	Huron Co. Canning Score (1-5)	Seed Size (Seeds/lb.)
12039	102	54*	3,483*	2,870*	3,795*	2,570	3,224	3,303	3,166	2.8	3.1	2173
14075	101	61*	3,231*	2,845*	3,193	2,519	2,947	NA [a]	NA	3.0	2.3	2233
14078	101	73	3,515*	2,771*	2,585	3,370**	3,061	3,124	NA	2.5	2.5	2118
14084	101	55*	3,238*	2,321	3,458	2,455	2,868	3,039	3,088	3.2	3.4	2127
16113	99	64	3,145	2,325	2,677	3,346*	2,873	NA	NA	3.8	4.1	2088
213SP	99	76	2,918	2,465	2,985	2,643	2,753	NA	NA	3.0	2.7	2248
Argosy	99	45*	3,142	2,337	2,640	2,687*	2,708	3,076	2,934	3.2	3.1	1950
Armada (13068)	99	54*	2,779	2,767*	2,754	3,050*	2,838	3,109	3,026	3.8	2.8	1944
Blizzard	98	66	3,324*	2,704	2,335	2,303	2,667	3,101	3,107	2.6	2.9	2152
EX1802-N	96	73	2,848	1,888	2,013	2,296	2,172	2,369	2,447	4.3	3.8	2243
EX1803-N	92	57*	2,338	1,961	1,968	2,677	2,236	2,359	2,525	3.3	3.4	2162
EX1804-N	99	62*	2,706	1,918	2,147	2,343	2,193	2,749	2,577	3.5	2.8	2342
EX1914-N	98	57*	2,646	2,130	2,327	2,062	2,291	NA	NA	2.8	2.6	2299
EX2109-N	97	75	2,811	2,275	2,028	2,373	2,371	NA	NA	2.0	2.9	2043
HMS Bounty	100	43**	3,270*	3,111*	3,780*	2,864*	3,256*	3,435*	3,355*	2.7	3.3	2242
HMS Medalist	101	48*	3,539*	2,683	3,778*	2,831*	3,208	3,310	3,282	2.8	2.7	2132
Liberty (15095)	101	53*	3,638**	3,159*	4,599**	3,040*	3,609**	3,611**	3,509**	3.1	3.8	2097
Merlin	103	49*	2,500	2,346	2,005	1,956	2,133	2,553	2,574	2.4	2.0	2242
N18103	97	76	2,984	2,406	2,949	2,709*	2,695	3,102	2,901	2.6	2.2	1397
N19246	97	58*	3,078	2,962*	3,249	3,105*	3,098	3,354	NA	2.5	2.6	2121
N20388	98	75	3,023	3,079*	2,818	2,554	2,869	3,058	NA	3.3	3.0	2124
N20395	98	79	3,093	2,877*	3,433	3,330*	3,184	NA	NA	2.2	3.1	2218
N20404	97	73	2,827	2,238	2,929	2,341	2,563	3,101	NA	3.5	3.8	2288
N21511	99	76	2,755	2,570	2,680	3,022*	2,757	NA	NA	3.1	2.9	2248
N21525	98	73	2,893	3,179**	2,488	2,662	2,805	NA	NA	2.5	2.9	2247
Nautica	98	69	2,802	2,760*	2,557	2,637	2,689	3,074	2,974	2.8	2.4	2416
ND Polar	100	56*	2,986	2,564	3,486	2,255	2,822	NA	NA	3.2	3.5	1743
Rogue	99	72	2,993	2,555	2,772	2,126	2,611	3,090	NA	4.0	2.7	1899
SV1893GH	101	55*	3,132	2,580	2,179	3,054*	2,736	3,221	3,048	2.7	2.5	1897
T9905	100	49*	2,223	2,262	2,714	2,592	2,445	NA	NA	2.5	2.9	1620
Valiant (08077)	98	59*	2,676	2,360	3,751*	3,180*	2,947	2,984	2,992	4.1	3.8	2091
Victory (15094)	99	71	3,226*	2,581	2,444	2,796*	2,762	3,186	3,137	3.1	2.9	2030
Vigilant	95	57*	3,229*	2,966*	2,637	2,973*	3,017	3,061	2,962	3.9	3.5	2018
MEAN:	99	62	2,999	2,570	2,853	2,688	2,769	3,059	2,978	3.1	3.0	2097
LSD$_{(0.05)}$:	*NA*	19	465	471	880	690	378	234	192	NA	NA	NA
CV:	*NA*	37.6%	13.2%	15.6%	26.6%	21.6%	23.2%	18.5%	19.2%	NA	NA	NA

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk.

[a] NA = Not available.

Table 6. Black bean agronomic, yield and canning results.

ENTRY	Maturity (DAP)	White Mold Infection (%)	Bay (Lbs./A)	Huron (Lbs./A)	Sanilac (Lbs./A)	Tuscola (Lbs./A)	1-year avg. (Lbs./A)	2-year avg. (Lbs./A)	3-year avg. (Lbs./A)	Bay Co. Canning Score (1-5)	Huron Co. Canning Score (1-5)	Seed Size (Seeds/lb.)
15619	102	53	3,444	3,318*	4,379*	2,325	3,367	3,314	3,367	3.7 (4.0)[a]	3.1 (4.1)	2148
16590	102	33*	3,467	2,801	3,881	3,273*	3,356	3,515*	3,390	3.0 (3.4)	2.6 (3.7)	1928
16598	100	80	3,496	3,123	4,134*	3,194*	3,487	*NA*[a]	*NA*	2.6 (2.5)	2.3 (2.6)	2055
16648	101	76	3,631*	2,765	4,044*	3,077*	3,380	3,469	3,363	3.3 (2.9)	1.9 (2.4)	1753
17715	100	76	3,200	2,625	3,860	3,182*	3,217	3,416	3,315	3.8 (4.1)	3.1 (3.7)	2073
17751	101	75	3,664*	3,195*	4,549**	3,721**	3,782*	3,756**	3,672*	3.9 (2.5)	3.3 (2.1)	1922
Adams	101	46	3,707*	2,834	3,659	2,635	3,209	3,536*	3,531*	3.2 (2.4)	2.8 (2.4)	2023
B18094173	99	43	3,585*	2,912	4,184*	3,265*	3,487	*NA*	*NA*	4.2 (4.4)	3.2 (4.5)	1691
B19309	100	73	3,809*	2,820	4,039*	3,048*	3,429	3,598*	*NA*	3.5 (3.0)	3.4 (2.7)	2068
B19344	101	74	3,574*	3,022	3,847	3,068*	3,378	3,603*	3,492	3.9 (4.7)	3.5 (4.6)	1900
B20536	101	39*	3,500	3,378*	3,354	3,546*	3,445	*NA*	*NA*	3.6 (3.4)	2.8 (3.3)	1880
B20547	100	24*	3,417	2,809	3,521	2,404	3,038	3,387	*NA*	4.0 (3.4)	2.8 (3.6)	1978
B20591	100	21**	3,089	2,801	3,458	2,899	3,062	3,570*	*NA*	3.4 (3.7)	2.9 (3.6)	1961
B20599	100	60	3,471	3,049	4,234*	3,245*	3,500	*NA*	*NA*	3.6 (3.7)	2.6 (3.6)	2045
B21708	100	78	3,411	2,517	3,482	3,570*	3,245	*NA*	*NA*	3.4 (3.1)	2.8 (2.6)	1798
B21710	101	63	3,568*	3,320*	3,857	3,331*	3,519*	*NA*	*NA*	3.5 (3.4)	2.9 (2.8)	2001
B21714	99	36*	3,689*	3,235*	3,543	2,499	3,242	*NA*	*NA*	3.7 (3.9)	3.8 (4.0)	1924
B3033350	94	61	3,238	2,246	2,308	2,295	2,522	*NA*	*NA*	2.3 (2.5)	2.9 (2.3)	2004
B3035411	96	56	3,506	3,068	3,751	3,513*	3,460	*NA*	*NA*	3.4 (2.5)	3.0 (2.6)	1892
B3036381	97	80	2,860	2,823	3,511	2,744	2,984	3,146	3,117	3.4 (4.2)	3.0 (3.9)	2178
B5058320	97	64	3,216	2,987	3,235	2,090	2,882	*NA*	*NA*	3.4 (2.9)	3.5 (2.8)	1892
B7071259	94	52	3,862*	3,402*	4,016*	2,802	3,520*	*NA*	*NA*	3.6 (3.1)	3.8 (2.5)	1901
B7072269	95	63	3,664*	2,967	4,082*	3,047*	3,440	*NA*	*NA*	4.1 (4.4)	3.1 (4.1)	1988
BL1726-2	97	43	3,301	2,767	3,225	1,874	2,792	3,222	*NA*	4.0 (4.4)	3.0 (4.1)	1940
Black Bear	102	41*	3,814*	3,331*	3,940	3,705*	3,697*	3,425	3,358	2.7 (2.5)	2.1 (2.4)	1978
Black Tails	102	69	3,072	2,857	3,287	3,508*	3,181	3,177	3,160	2.6 (3.2)	2.6 (2.5)	2110
BlackBeard	101	67	3,107	3,329*	4,186*	2,237	3,215	3,395	3,449	3.8 (4.7)	3.5 (4.2)	1802
ND Twilight	95	99	2,359	1,842	2,171	1,826	2,049	2,592	2,529	2.9 (2.2)	2.4 (2.6)	2035
Nimbus (14500)	101	61	4,071**	3,655**	4,401*	3,468*	3,899**	3,693*	3,738**	2.5 (2.9)	2.6 (2.1)	1916
OAC Vortex	99	66	3,317	3,009	3,803	2,779	3,227	*NA*	*NA*	3.2 (2.6)	2.6 (2.9)	1872
Spectre (14497)	102	24*	3,345	3,225*	3,976	3,000*	3,387	3,394	3,460	3.3 (3.0)	2.7 (2.9)	1744
Zenith	100	25*	3,374	3,243*	4,106*	3,068*	3,448	3,557*	3,414	4.3 (4.4)	4.1 (4.7)	1449
Zorro	99	51	2,969	2,892	3,378	3,071*	3,078	3,246	3,182	3.7 (3.1)	3.4 (3.1)	1963
MEAN:	99	57	3,418	2974	3,739	2,948	3,270	3,400	3,346	3.4 (3.4)	3.0 (3.2)	1934
LSD(0.05):	*NA*	20	561	467	571	721	372	243	187	NA	NA	NA
CV:	*NA*	34%	13.9%	13.3%	13.0%	20.8%	19.5%	17.3%	16.6%	NA	NA	NA

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk. [a] *Canning scores for black beans are notated as general appearance followed by color. Example: appearance (color)*

[a] NA = Not available.

Table 7. Small red and pink bean agronomic, yield and canning results.

ENTRY	Maturity *(DAP)*	White Mold Infection *(%)*	Bay *(Lbs./A)*	Huron *(Lbs./A)*	Sanilac *(Lbs./A)*	Tuscola *(Lbs./A)*	1-year avg. *(Lbs./A)*	2-year avg. *(Lbs./A)*	3-year avg. *(Lbs./A)*	Bay Co. Canning Score *(1-5)*	Huron Co. Canning Score *(1-5)*	Seed Size *(Seeds/lb.)*
16686	97	84	2,998	2,499	3,437	2,870*	2,951	3,249*	3,096	4.2	3.2	1178
17822	97	77	3,374	3,515*	4,083*	3,327*	3,574*	*NA* [a]	*NA*	2.5	3.2	1432
17837	98	93	2,885	3,236*	2,715	1,914	2,688	3,000	2,917	2.9	2.4	1299
17875	99	93	2,818	3,102*	3,975*	2,359	3,064	3,251*	*NA*	3.5	3.1	1232
19837	96	73	3,252	2,960	3,713	3,038*	3,241	*NA*	*NA*	3.5	2.5	1340
Coral	100	48**	2,711	2,985	3,107	3,055*	2,965	3,012	2,829	2.5	3.2	1194
R20627	100	51*	2,538	2,459	2,749	2,597	2,577	3,036	*NA*	3.2	3.8	1198
R20667	100	74	2,801	3,117*	2,839	2,894*	2,913	3,199*	*NA*	3.4	4.0	1302
R20669	101	71	3,900**	3,618**	4,407*	3,393**	3,829**	*NA*	*NA*	2.5	2.4	1325
Rosetta	99	86	3,117	2,656	2,680	2,946*	2,837	3,060	*NA*	*2.3*	2.2	*1872*
Ruby	99	77	3,138	2,909	3,999*	2,226	3,068	3,947	2,857	3.3	2.2	1463
Viper	100	85	3,739*	3,287*	4,547**	3,074*	3,536*	3,421**	3,329**	4.4	3.0	1875
MEAN:	99	76	3,105	3,028	3,521	2,808	3,103	3,131	3006	3.2	2.9	1393
LSD$_{(0.05)}$:	*NA*	16.6	428	562	809	731	396	283	202	NA	NA	NA
CV:	*NA*	26.2%	11.53%	15.5%	19.2%	21.7%	21.6%	21.9%	19.9%	NA	NA	NA

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk.

[a] NA = Not available.

Table 8. Pinto bean agronomic, yield and canning results.

ENTRY	Maturity (DAP)	White Mold Infection (%)	Bay (Lbs./A)	Huron (Lbs./A)	Sanilac (Lbs./A)	Tuscola (Lbs./A)	1-year avg. (Lbs./A)	2-year avg. (Lbs./A)	3-year avg. (Lbs./A)	Bay Co. Canning Score (1-5)	Huron Co. Canning Score (1-5)	Seed Size (Seeds/lb.)
Bronco (41767-15)	96	74*	2021	2226	2342	2283	2218	*NA* [a]	*NA*	2.2	2.0	1063
Charro	101	85*	3,441*	2,882*	4,241**	3,336*	3,621**	3,546**	3,532**	3.8	4.4	1123
EX1844-P	95	72*	1,977	1,952	1,543	3,100*	2,189	*NA*	*NA*	4.3	3.8	1138
EX1845-P	96	79*	2,311	2,090	1,264	2,566	1,911	*NA*	*NA*	4.1	4.0	1282
EX2143-P	98	68*	2,982	3,021*	2,577	2,867	2,862	*NA*	*NA*	2.3	3.7	1247
EX2146-P	99	81*	3,004	2,830*	2,562	2,862	2,814	*NA*	*NA*	2.5	3.3	1272
EX2147-P	98	75*	2,788	2,184	2,501	2,881	2,588	*NA*	*NA*	2.2	4.4	1347
LaPaz	96	95	2,910	2,982*	3,491	3,038	3,105	3,250	3,268	2.6	3.5	1224
ND Falcon	100	75*	2,921	3,073**	3,011	3,019	3,006	2,806	2,839	2.7	3.7	1792
ND Palomino	98	77*	2,828	2,044	2,020	2,610	2,375	2,806	2,846	3.8	2.9	1185
P19103	102	63**	3,420*	2,660	3,850*	2,679	3,152	3,538*	3,468*	4.2	3.6	1639
P19713	98	83*	3,635**	2,801*	3,485	3,626**	3,488*	3,485*	*NA*	3.4	3.7	1229
SV6139GR	96	88	2,824	2,924*	2,268	2,805	2,705	3,211	3,168	3.2	3.5	1527
Windbreaker	97	93	1,858	2,103	1,555	2,665	1,960	2,355	3,440	2.8	3.5	1349
MEAN:	98	79	2,780	2,555	2,622	2,881	2,714	3,125	3,080	3.2	3.6	1361
LSD$_{(0.05)}$:	*NA*	23.9	520	619	622	544	370	270	204	NA	NA	NA
CV:	*NA*	25.5%	15.7%	20.3%	19.9%	15.8%	23.1%	20.9%	19.7%	NA	NA	NA

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk.

[a] NA = Not available.

Table 9. Great northern bean agronomic, yield and canning results.

ENTRY	Maturity *(DAP)*	White Mold Infection *(%)*	Bay *(Lbs./A)*	Huron *(Lbs./A)*	Sanilac *(Lbs./A)*	Tuscola *(Lbs./A)*	1-year avg. *(Lbs./A)*	2-year avg. *(Lbs./A)*	3-year avg. *(Lbs./A)*	Bay Co. Canning Score *(1-5)*	Huron Co. Canning Score *(1-5)*	Seed Size *(Seeds/lb.)*
Aries	95	79	2,140	2,436	2,499	2,730*	2,391	2,466	2,392	3.3	2.6	1211
Eiger	99	59**	2,733*	3,071*	3,710*	3,318**	3,208*	3,277	3,321*	3.1	3.0	1368
G19613	99	63*	3,023*	3,021*	3,881*	3,300*	3,306*	3,455*	*NA* [a]	3.4	3.8	1214
G21811	98	63*	3,157**	3,172*	3,396*	3,247*	3,352*	*NA*	*NA*	4.2	3.4	1318
ND Pegasus	100	69*	2,970*	3,395**	4,027**	2,609*	3,477**	3,586**	3,448**	3.2	3.2	1096
Powderhorn	93	72*	2,662	2,911	2,774	2,716*	2,688	2,809	2,730	3.2	2.6	1268
MEAN:	97	67	2,781	3,001	3,381	2,987	3,070	3,118	2,973	3.4	4.0	1246
LSD$_{(0.05)}$:	*NA*	19.8	706	475	685	783	341	235	215	NA	NA	NA
CV:	*NA*	34.8%	20.2%	12.6%	16.3%	21.0%	18.7%	18.2%	21.4%	NA	NA	NA

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk.

[a] NA = Not available.

Table 10. Cranberry bean agronomic, yield and canning results.

ENTRY	Maturity *(DAP)*	White Mold Infection *(%)*	Montcalm *(Lbs./A)*	Tuscola *(Lbs./A)*	Irrigated 2-year avg. *(Lbs./A)*	Irrigated 3-year avg. *(Lbs./A)*	Dry Land 2-year avg. *(Lbs./A)*	Dry Land 3-year avg. *(Lbs./A)*	Canning Score *(Montcalm 1-5)*	Seed Size *(Seeds/lb.)*
16756	92	68	2,442	1,726*	2,961	2,783	1,922	1,991	4.3	1081
16758	90	73	2,608	1,298	3,119	3,003	1,747	1,826	4.2	1053
16775	99	41*	2,601	1,428	2,811	2,771	1,728	1,927	3.2	901
16816	82	97	2,664	1,627	3,085	3,038	1,787	2,013	2.8	981
151093	98	74	3,225*	1,910*	3,543*	3,340*	2,359*	2,476*	2.4	852
AAC Scotty	96	57*	2,620	2,158*	2,754	*NA* [a]	2,298*	*NA*	2.1	811
Amaranto (SV3709GC)	87	71	3,030*	2,079*	3,179*	3,074	1,985	2,071	2.5	868
CR1801-2-2	91	50*	2,731	1,811*	*NA*	*NA*	*NA*	*NA*	3.2	908
ETNA	91	83	3,006*	1,525	3,580**	3,454**	1,937	2,103	2.4	850
Firestripe	99	62*	3,299**	1,705	*NA*	*NA*	*NA*	*NA*	2.4	722
Jester (151085)	100	78	2,833*	2,126*	3,142	3,076	2,505**	2,554**	1.9	752
Navabi	96	38**	3,273*	2,219**	*NA*	*NA*	*NA*	*NA*	1.7	844
Vero	88	85	3,109*	2,113*	3,390*	3,214*	2,102	2,078	3.3	950
MEAN:	93	67	2,880	1,786	3,156	3,084	2,037	2,115	2.8	890
LSD$_{(0.05)}$:	*NA*	26	561	504	396	289	319	283	NA	NA
CV:	*NA*	32.3%	16.3%	23.6%	15.0%	13.8%	18.7%	18.0%	NA	NA

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk.

[a] NA = Not available.

Table 11. Light red kidney bean agronomic, yield and canning results.

ENTRY	Maturity (DAP)	White Mold Infection (%)	Montcalm (Lbs./A)	Tuscola (Lbs./A)	Irrigated 2-year avg. (Lbs./A)	Irrigated 3-year avg. (Lbs./A)	Dry Land 2-year avg. (Lbs./A)	Dry Land 3-year avg. (Lbs./A)	Canning Score (Montcalm 1-5)	Seed Size (Seeds/lb.)
11413	91	56	3,641*	1,568	3,708*	NA [a]	1,972	NA	3.2	778
15916	89	74	3,445	1,874*	3,590	NA	2,310	NA	2.5	857
15923	95	69	3,829*	1,573	3,964**	NA	1,953	NA	2.7	704
16998	98	65	3,294	1,557	3,654*	NA	2,058	NA	2.5	684
161082	91	65	3,957**	1,686	3,861*	NA	2,057	NA	3.1	750
Big Red	91	88	3,244	1,793	3,495	3,486**	2,272	2,245*	2.8	714
California Early	87	86	3,628*	1,418	3,469	3,434*	1,709	1,771	3.4	783
Clouseau	100	74	3,356	1,816	3,497	3,266*	2,091	2,100	3.5	735
K20743	100	76	3,429	1,808	3,779*	NA	2,509*	NA	2.7	870
K20745	99	68	3,466	2,005*	NA	NA	NA	NA	2.5	835
L1032326	100	63	3,060	2,016*	NA	NA	NA	NA	1.8	709
Pink Panther	98	74	3,237	1,564	3,423	3,371*	1,964	2,057	2.3	752
PO76D1	100	31*	3,649*	2,194*	NA	NA	NA	NA	2.9	707
Red Dawn (09363)	87	77	3,426	1,417	3,365	3,393*	2,081	2,127	2.2	685
Ronnie's Red	105	28**	3,595*	2,206**	2,943	2,552	2,643**	2,582**	3.2	724
MEAN:	95	66	3,428	1,766	3,562	3,250	2,135	2,147	2.8	751
LSD$_{(0.05)}$:	NA	17	428	341	367	355	299	368	NA	NA
CV:	NA	22.6%	10.3%	16.2%	12.3%	16.0%	16.8%	22.8%	NA	NA

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk.

[a] NA = Not available.

Table 12. Dark red kidney bean agronomic, yield and canning results.

ENTRY	Maturity *(DAP)*	White Mold Infection *(%)*	Montcalm *(Lbs./A)*	Tuscola *(Lbs./A)*	Irrigated 2-year avg. *(Lbs./A)*	Irrigated 3-year avg. *(Lbs./A)*	Dry Land 2-year avg. *(Lbs./A)*	Dry Land 3-year avg. *(Lbs./A)*	Canning Score *(Montcalm 1-5)*	Seed Size *(Seeds/lb.)*
15977	100	86	2,813	1,608	3,022	3,001	2,204	2,231	1.8	712
15978	103	81	2,649	2,010	2,129	2,315	2,135	2,226	2.8	870
151011	97	81	2,810	1,922	3,359*	3,302*	2,242	2,232	2.9	1058
161156	90	81	3,111	1,907	3,593*	3,423*	2,277	2,369	3.3	942
161164	100	84	3,365*	1,902	3,433*	3,217*	2,153	2,271	2.5	849
181017	101	85	3,662**	1,778	3,762**	3,373*	2,340	2,247	2.8	790
181020	92	88	3,436*	1,506	3,033	*NA* [a]	1,761	*NA*	4.1	749
181021	87	88	3,455*	1,736	3,186	*NA*	2,076	*NA*	2.8	732
D1034333	98	70	2,766	1,679	*NA*	*NA*	*NA*	*NA*	3.3	858
Dynasty	100	75	3,522*	2,504**	3,748*	3,485**	2,746**	2,713**	1.7	733
Epic	104	68*	3,525*	2,235*	3,474*	3,224*	2,360	2,364	2.7	773
Gallantry	100	50**	3,204	2,006	3,479*	*NA*	2,338	*NA*	2.9	852
K20217	100	74	2,716	1,609	*NA*	*NA*	*NA*	*NA*	1.5	792
K20221	98	52*	2,722	1,785	*NA*	*NA*	*NA*	*NA*	3.4	915
Montcalm	102	62*	3,050	1,690	2,901	2,844	2,178	2,211	3.5	811
Rampart (09434)	97	67*	3,163	1,667	3,384*	3,135*	2,208	2,271	2.2	915
Red Hawk	101	65*	3,267	1,669	3,261*	3,155*	1,624	1,705	3.0	833
Red Rover	98	67*	2,933	1,715	2,905	2,915	2,134	2,163	2.5	784
MEAN:	98	73	3,120	1,845	3,244	3,116	2,185	2,250	2.8	833
LSD$_{(0.05)}$:	*NA*	19	342	392	519	382	358	319	NA	NA
CV:	*NA*	21.9%	9.2%	17.9%	19.2%	18.1%	19.7%	19.1%	NA	NA

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk.

[a] NA = Not available.

Table 13. White kidney bean agronomic, yield and canning results.

ENTRY	Maturity (DAP)	White Mold Infection (%)	Montcalm (Lbs./A)	Tuscola (Lbs./A)	Irrigated 2-year avg. (Lbs./A)	Irrigated 3-year avg. (Lbs./A)	Dry Land 2-year avg. (Lbs./A)	Dry Land 3-year avg. (Lbs./A)	Canning Score (Montcalm 1-5)	Seed Size (Seeds/lb.)
Beluga	102	9	2,891	1,502	2,670	2,563	2,116	2,145	2.1	801
Denali	97	34	3,549*	1,651	3,529**	3,535**	2,279	2,238	2.2	775
K19830	102	26	3,749*	1,922*	3,496*	3,310*	2,640*	2,619**	1.8	739
K19831	101	24	3,568*	2,077*	3,171*	*NA*	2,665**	*NA*	2.2	715
K19832	100	27	3,667*	1,701	*NA* [a]	*NA*	*NA*	*NA*	2.0	680
ND Whitetail	100	40	3,023	2,141**	3,052	2,992	2,538*	2,416	1.9	822
Snowdon	94	55	3,303	1,376	3,344*	*NA*	1,889	*NA*	2.2	682
Snowshoe	105	56	3,806**	1,774	*NA*	*NA*	*NA*	*NA*	1.8	758
WK1601-1	94	56	3,403*	1,602	*NA*	*NA*	*NA*	*NA*	2.7	885
Yeti	104	32	3,032	2,018*	3,034	2,715	2,467*	2,367	1.8	801
MEAN:	100	35	3,399	1,776	3,185	3,023	2,371	2,357	2.1	766
LSD(0.05):	*NA*	NS	459	332	432	290	208	195	NA	NA
CV:	*NA*	-	11.1%	15.4%	16.1%	13.9%	10.4%	10.9%	NA	NA

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk.

[a] NA = Not available.

Table 14. Mayocoba/yellow bean agronomic, yield and canning results.

ENTRY	Maturity (DAP)	White Mold Infection (%)	Montcalm (Lbs./A)	Tuscola (Lbs./A)	Irrigated 2-year avg. (Lbs./A)	Irrigated 3-year avg. (Lbs./A)	Dry Land 2-year avg. (Lbs./A)	Dry Land 3-year avg. (Lbs./A)	Canning Score (Montcalm 1-5)	Seed Size (Seeds/lb.)
Claim Jumper (13655)	106	90*	2,395	2,181*	2,757	2,623	2,602**	2,423**	3.7	1013
Motherlode (191274)	102	89*	1,889	1,791	1,893	*NA* [a]	2,118	*NA*	3.9	944
Y1608-14	90	98	2,546	1,899	2,736	2,677	1,897	1,984	2.2	1146
Y1702-22	92	70**	3,309**	1,626	3,226**	2,981**	1,975	2,091*	2.2	1107
Y1960-1-1	93	76*	1,427	2,385**	*NA*	*NA*	*NA*	*NA*	3.9	1066
Y19810	105	71*	2,751	2,162*	*NA*	*NA*	*NA*	*NA*	2.4	1110
Yellowstone	92	93*	2,510	1,578	2,714	2,756*	2,205	2,194*	3.6	1127
MEAN:	97	84	2,404	1,945	2,554	2,743	2,159	2,173	3.1	1073
LSD(0.05):	*NA*	24	395	345	295	255	304	345	NA	NA
CV:	*NA*	23.5%	13.4%	14.3%	13.6%	13.4%	16.5%	22.1%	NA	NA

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk.

[a] NA = Not available.

2022 Sourcing Information

Table 15. Sources of dry bean entries tested in the 2022 performance trials, organized by market class.

Entry ID	Market Class	Source
15619	BL	ProVita
16590	BL	ProVita
16598	BL	ProVita
16648	BL	ProVita
17715	BL	ProVita
17751	BL	ProVita
Adams	BL	MSU [a]
B18094173	BL	ADM [b]
B19309	BL	MSU
B19344	BL	MSU
B20536	BL	MSU
B20547	BL	MSU
B20591	BL	MSU
B20599	BL	MSU
B21708	BL	MSU
B21710	BL	MSU
B21714	BL	MSU
B3033350	BL	ADM
B3035411	BL	ADM
B3036381	BL	ADM
B5058320	BL	ADM
B7071259	BL	ADM
B7072269	BL	ADM
BL1726-2	BL	USDA
Black Bear	BL	ProVita
Black Tails	BL	ProVita
BlackBeard (14506)	BL	ProVita
ND Twilight	BL	NDSU [c]
Nimbus (14500)	BL	ProVita
OAC Vortex	BL	University of Guelph
Spectre (14497)	BL	ProVita
Zenith	BL	MSU
Zorro	BL	MSU
151093	CR	ProVita
16756	CR	ProVita
16758	CR	ProVita
16760	CR	ProVita
16775	CR	ProVita
16816	CR	ProVita
AAC Scotty	CR	Meridian Seeds
Amaranto (SV3709GC)	CR	Bayer
CR1801-2-2	CR	USDA
Etna	CR	Bayer
Firestripe	CR	TVS [d]
Jester (151085)	CR	ProVita
Navabi	CR	TVS
Vero	CR	ADM
151011	DRK	ProVita
15977	DRK	ProVita
15978	DRK	ProVita
161156	DRK	ProVita
161164	DRK	ProVita
181017	DRK	ProVita
181020	DRK	ProVita
181021	DRK	ProVita
D1034333	DRK	ADM
Dynasty	DRK	Hensall Co-op
Epic	DRK	ProVita
Gallantry	DRK	Hensall Co-op
K20217	DRK	MSU
K20221	DRK	MSU
Montcalm	DRK	MSU
Rampart (09434)	DRK	ProVita
Red Hawk	DRK	MSU
Red Rover	DRK	Bayer
Eiger	GN	MSU
G19613	GN	MSU
G21811	GN	MSU
ND Pegasus	GN	NDSU
Powderhorn	GN	MSU
11413	LRK	ProVita
15916	LRK	ProVita
15923	LRK	ProVita
161082	LRK	ProVita

Entry ID	Market Class	Source
16998	LRK	ProVita
Big Red	LRK	ProVita
California Early	LRK	University of California
Clouseau	LRK	Bayer
K20743	LRK	MSU
K20745	LRK	MSU
L1032326	LRK	ADM
Pink Panther	LRK	Bayer
Red Dawn (09363)	LRK	ProVita
Ronnie's Red	LRK	ProVita
Claim Jumper (13655)	MY	ProVita
Motherlode (191274)	MY	ProVita
Y1608-14	MY	USDA-ARS [e]
Y1702-22	MY	USDA-ARS
Y1960-1-1	MY	USDA
Y19810	MY	MSU
Yellowstone	MY	MSU
12039	NA	ProVita
14075	NA	ProVita
14078	NA	ProVita
14084	NA	ProVita
16113	NA	ProVita
213SP	NA	Gentec
Argosy	NA	Hensall Co-op
Armada (13068)	NA	ProVita
Blizzard	NA	ProVita
EX1802-N	NA	TVS
EX1803-N	NA	TVS
EX1804-N	NA	TVS
EX1914-N	NA	TVS
EX2109-N	NA	TVS
HMS Bounty (12047)	NA	ProVita
HMS Medalist	NA	ProVita
Liberty (15095)	NA	ProVita
Merlin	NA	ProVita
N18103	NA	MSU
N19246	NA	MSU
N20388	NA	MSU
N20395	NA	MSU
N20404	NA	MSU
N21511	NA	MSU

Entry ID	Market Class	Source
N21525	NA	MSU
Nautica	NA	Hensall Co-op
ND Polar	NA	NDSU
Rogue	NA	Hensall Co-op
SV1893GH	NA	Bayer
T9905	NA	TVS
Valiant (08077)	NA	ProVita
Victory (15094)	NA	ProVita
Vigilant	NA	ADM
Bronco (41767-15)	P	TVS
Charro	P	MSU
EX1844-P	P	TVS
EX1845-P	P	TVS
EX2143-P	P	TVS
EX2146-P	P	TVS
EX2147-P	P	TVS
LaPaz	P	ADM
ND Falcon	P	NDSU
ND Palomino	P	NDSU
P19103	P	MSU
P19713	P	MSU
SV6139GR	P	Bayer
Windbreaker	P	Bayer
Coral	PI	MSU
Rosetta	PI	MSU
PO76D1	SO	Gentec
16686	SR	ProVita
17822	SR	ProVita
17837	SR	ProVita
17875	SR	ProVita
19837	SR	ProVita
R20627	SR	MSU
R20667	SR	MSU
R20669	SR	MSU
Ruby	SR	ProVita
Viper	SR	ProVita
Beluga	WK	ADM
Denali	WK	MSU
K19830	WK	MSU
K19831	WK	MSU
K19832	WK	MSU

Entry ID	Market Class	Source
ND Whitetail	WK	NDSU
Snowdon	WK	MSU
Snowshoe	WK	TVS
WK1601-1	WK	USDA
Yeti	WK	Hensall Co-op

Note. Bean entries are listed alphabetically within market classes. BL = black, CR = cranberry, DRK = dark red kidney, GN = great northern, LRK = light red kidney, MY = mayocoba/yellow, NA = navy, P = pinto. PI = pink, SO = soldier, SR = small red, WK = white kidney.

[a] MSU = Michigan State University

[b] ADM = Archer-Daniels-Midland

[c] NDSU = North Dakota State University

[d] TVS = Treasure Valley Seed

[e] USDA-ARS = U.S. Dept. of Agriculture – Agricultural Research Service

Longitudinal assessment of variability comprehensive analysis (year 2 of 3)

Scott Bales, MSU Dry Bean Specialist &

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Introduction:

Black and Pinto beans are the most important dry bean market classes in North America. There continues to be strong demand both domestically and internationally for high- quality Michigan grown beans. Many of these beans go to the canning market. However, there are significant and unique challenges to dry bean quality after thermal processing for both the black and pinto market classes. Black bean color is derived from anthocyanins present in the seed coat; however anthocyanins can readily leach into the water or brine during processing. This can leave the end-product a light shade of red-brown rather than the deep black color that is desirable. A second measurable trait that is important to processing quality is the overall appearance of the bean (water uptake, splits, and texture). As the industry advances to meet increased demand it is essential that we understand processing quality of newly adopted varieties in both market classes, and how they compare to current market standards. Identification and validation of unique quality characteristics in both commercial black and pinto market classes is essential for the success of the entire dry bean supply chain.

Materials and Methods:

Six black bean (Nimbus, Adams, Black Beard, Spectre, Zenith, and Zorro) and three pinto bean (Charro, LaPaz, and Windbreaker) varieties were selected for testing. Varieties were chosen to represent both commercial standards for processing quality, as well as new varieties that commercial dry bean growers are beginning to adopt based on improved agronomic traits. All nine varieties were planted at two separate locations in Michigan in 2020, 2021, and 2022. These locations were near Kawkawlin, MI (Bay County), Colling, MI (Tuscola County), Ruth, MI (Huron County), and Pigeon, MI (Huron County) within fields of commercial production depending on the year. All locations are in the traditional dry bean production region of Michigan comprised of the Thumb and Saginaw Valley. The remainder of this report will focus on the 2020 and 2021 growing seasons, as 2022 technical analysis is still underway.

Dry beans were seeded at 130,000 seeds per acre in a plot size of 6.6'x20'. This plot size consists of 4-row plots at 20-inch row spacing. Trial design was a randomized complete block design with four replications at all locations. Planting dates were June 7,2020 in Bay County and June 6, 2020 in Tuscola County. In 2021 dry beans were planted on May 31st in Bay County and June 11th in Huron County. Since differing county locations were used between years, for the remainder of this report locations will be referred to as Eastern (Huron and Tuscola) and Western (Bay County). Standard agronomic practices were followed to ensure optimal growing conditions until harvest. Seed was direct harvested from both market classes utilizing a Wintersteiger Quantum combine in September of both years. Cleaned seed weight from each plot was recorded and used to calculate yield per acre in pounds adjusted to 18% moisture.

Dry bean samples were canned using a standard research protocol developed at MSU. Three field replicates from each variety were used to create individual replications for each variety

within a location. For each replicate, a moisture adjusted subsample equivalent to 115-g solids was prepared. Black bean samples were than blanched for 90 seconds, and pinto beans 5 minutes in a steam kettle at 200ºF in tap water following a prior 8 hour cold soak. Hydration coefficients (HC) were then calculated as the ratio of sample weight after soaking to the weight of the original dry seed. The soaked beans were then canned in 307 x 407 tin cans in 200ºF brine. Brine was formulated utilizing tap water with 1.5% sucrose, 1.2% sodium chloride and 0.005% calcium chloride added. The cans were then sealed and processed in an 'Allpax' retort. Thermal processing was conducted for 19 minutes at 250F and rotated one time during cool down. Cans were allowed to rest and equilibrate for approximately four weeks prior to opening. Upon opening bean samples were visually evaluated for overall appearance (seed shape, splits, clumps and color) on a 5 point scale as follows: 5= excellent appearance, 4= very good appearance, 3= average appearance, 2= poor appearance, and 1=unacceptable appearance. For black beans appearance and color were visually scored separately on this same 5 point scale previously described. A colorimeter, Hunter Labscan XE was also used for extracting color parameters from drained black bean samples. For this analysis three measurements of color were considered: L*a*b*. In food research, color is frequently represented using the L*a*b* color space to match human perception (Sangwine 2000). L* is the lightness component that goes from 0 (black) to 100 (white), and parameters a* (from green to red) and b* (from blue to yellow) are the two chromatic components, varying from -120 to +120. The weight of the entire canned sample after draining and rinsing off the brine was also recorded. The ratio of this value to the soaked weight of the sample was determined and is referred to as the washed drained coefficient (WDC). Texture was measured by placing 100 g of each rinsed and drained canned sample into texture analyzer (model TA-XT, Texture Technologies, Hamilton, MA) with a shear-compression cell attachment. The Kramer Shear press uses a dynamic hydraulic system to determine the peak force needed for loss of total bean integrity. Values are reported as kg per 100 g. The ideal texture readings for beans are between 55 and 65 kg and higher values indicate firmer beans.

Statistical analysis of yield and phenotypic data was conducted in R utilizing analysis of variance procedure (ANOVA). Main effects and interactions were tested for at $\alpha<0.05$, when insignificant data were pooled over insignificant factors. Data were combined over years.

Results and Discussion:

Results for black beans and pinto beans were kept separate for analysis. Overall yield and first pass quality was above average for both county locations in both years of testing. Table 1 and 2 contain all numeric results for black and pinto beans. Tables 3 and 4 are ANOVA (analysis of variance) tables. ANOVA tables are useful in identifying significant factors and interactions for each variable tested. P-values less than 0.05 within the ANOVA table were considered significant and mean separation was performed in Tables 1 and 2.

Black Beans- Black bean yields were statistically different when combined over years and locations. The commercial entries 'Adams' and 'Nimbus' out yielded the remaining entries by 8-12% (Table 1). When combined over locations and years seed size in seeds per pound ranged from 1941- 2160. Hydration coefficients (HC) or the ratio of blanched seed weight (90 second blanch) to the original dry seed weight were greatest from Nimbus 1.22 (Table 1). However, all HC ratios ranged between 1.15-1.22 as hydration was limited by the brief 90 second blanch.

Washed drained weights (WDW) were significant for variety and location. WDC were highest for Zenith, Adams, and Zorro. Locations in the western growing area (Bay Co.) had significantly lower WDW coefficients than locations in the eastern growing area (Huron and Tuscola Co.) with values of 184 and 187, respectively ($\alpha<0.05$). The canned bean texture was significant for variety and variety by location interaction. Adams produced firmer textures in western locations than eastern. However, Black Beard and Zorro produced inverse results with firmer textures from eastern locations than western ($\alpha<0.05$). The remaining entries did not significantly respond to the interaction of variety by location and would be considered stable for the duration of this testing (2020-2021). Black bean color was evaluated both visually (rated by trained evaluators) and empirically using a colorimeter. Results from visual ratings indicated an interaction between variety and location. This indicates that there is a genetic by environmental effect in the color retention of black beans (Table 1). When values from colorimeter were analyzed, L* (darkness) values were only influenced by variety. Varieties grouped in three general groups. Darkest: Zenith and Black Beard (lowest L* values: 14.8-14.9); Medium: Zorro, Spectre, and Adams (18.1-18.7); Lightest: Nimbus (18.9). In a similar response to visual color ratings, appearance ratings were also impacted by variety and location. Overall, all varieties scored as average (3.0-4.0) in at least one location (Table 2). However, below average scores were noted in specific locations for Nimbus, Zorro, and Spectre.

Pinto Beans- Pinto bean yield was statistically different across years and locations. In both cases Charro and LaPaz out yielded Windbreaker by 16-26% (Table 2). Seed size was very similar between all entries, ranging from 1142-1240 seeds per pound. HC (hydration coefficients) as the ratio of blanched seed (5 min at 200F) to dry seed weight were affected by the interaction of variety by location ($\alpha<0.05$). This interaction was driven by the entry of Lapaz having lower HC values in western growing regions than eastern (Table 2). WDC (washed drained weight coefficient) was statistically affected by entry and not location. Texture was not affected by the variety, values ranged from 60.6-65.2 kg. Appearance scores were only impacted by the main effect of entry, values ranged from 3.0-2.4 ranking in order from best to worst: Charro, LaPaz, and Windbreaker.

Conclusion- From 2020-2021 results it appears that new varieties in both black and pinto market classes have maintained commercially acceptable canning quality. In regards to black bean color, superior color is maintained by varieties Zenith and Black Beard whereas Zorro, Spectre, Adams and Nimbus will produce color that is average to below average depending on environmental conditions. In 2022 research will have a greater focus on precise environmental and harvest conditions that can have an impact on a variety's unique characteristics such as color, texture, and appearance. Moving forward special attention should be paid to the color retention of both Adams and Nimbus as they are just beginning commercial adoption and should be closely monitored for quality over a greater geographic area and production volume. In the Pinto bean market class the new variety Charro has matched or surpassed the current commercial standard of LaPaz in appearance, texture, seed size and yield. Based on these results future adoption of the variety Charro will not have negative implications for processors.

This experiment was continued into 2022 and data is in the process of analysis to complete year 3 of this project.

Table 1. Black bean agronomic and phenotypic results for the 2020 and 2021 field seasons*.

Variety	Mat[1]	Flow[2]	Yield[3]	Seed Size	HC[4]	WDC[5]	Texture[6]		Color[7]		Appearance[8]		L*[9]	A*	B*
	– dap –	*– dap –*	*–Lb. A^{-1}–*	*seeds Lb^{-1}*			East[10]	West	East	West	East	West			
Adams	101	44	3318 a	2039	1.15 c	189.7 b	59.4 ef	62.9 bd	2.8 c	3.0 c	3.3 bc	3.6 ab	18.5 ab	7.4 a	5.3 a
Black Beard	100	47	3025 b	1942	1.19 b	186.8 d	66.5 a	61.9 ce	4.7 a	4.3 ab	3.7 ab	3.7 ab	14.9 c	6.1 b	2.8 a
Spectre	101	45	3152 ab	2075	1.19 b	186.2 e	65.9 ab	64.0 ac	2.6 c	3.0 c	2.3 d	3.0 c	18.7 ab	6.8 ab	4.8 a
Zenith	101	46	3011 b	1967	1.18 b	197.7 a	56.9 f	59.8 df	4.7 a	4.5 a	4.0 a	3.7 ab	14.8 c	6.2 b	2.4 c
Zorro	100	45	2938 b	2160	1.19 b	189.0 c	66.2 a	62.0 ce	3.1 c	3.8 b	2.8 cd	3.8 ab	18.1 b	7.2 a	3.7 b
Nimbus	101	46	3294 a	1941	1.22 a	172.5 f	64.6 ac	67.1 a	2.7 c	2.9 c	2.9 c	3.4 bc	18.9 a	7.0 a	5.2 a

[1] Dry bean maturity averaged across location is days after planting to physiological maturity
[2] Days from planting to flowering for each dry bean variety
[3] Dry bean yield in pounds per acre adjusted to 18% moisture
[4] HC (hydration coefficient): the ratio of the weight of blanched seed to dry seed
[5] WDC (washed drained weight coefficient): the ratio of the weight of rinsed and drained canned seed to the blanched seed weight
[6] Texture is measured on canned beans as force (kg) required to crush the sample
[7] Visual evaluation of color on a scale from 1-5 (1=unacceptable, 5=exceptional)
[8] Appearance the canned bean sample on a scale from 1-5 (1=unacceptable, 5=exceptional)
[9] L*, a*, b*: CIE Lab color scale, where L* represents lightness, a* represents red/green, and b* represents blue/yellow
[10] Eastern locations refer to Bay Co. in 2020 and 2021, Western locations include Tuscola Co. in 2020 and Huron in 2021
* Means followed by the same letter are not significantly different ($\alpha \leq 0.05$)

Table 2. Pinto bean agronomic and phenotypic data from the 2020 and 2021 field season*.

Variety	Mat[1]	Flow[2]	Yield[3]	Seed Size	HC[4]		WDC[5]	Texture[6]	Appearance[7]
	– dap –	*– dap –*	*–Lb. A^{-1}–*	*seeds Lb^{-1}*	East[8]	West			
Charro	103	45	3069 a	1181	1.90 a	1.89 a	113.2 c	60.6 a	3.0 a
LaPaz	98	46	2908 a	1240	1.67 b	1.58 d	133.9 a	63.9 a	2.6 b
Windbreaker	96	43	2430 b	1142	1.76 b	1.8 b	120.7 b	65.2 a	2.4 c

[1]Dry bean maturity averaged across location is days after planting to physiological maturity
[2] Days from planting to flowering for each dry bean variety
[3] Dry bean yield in pounds per acre adjusted to 18% moisture
[4] HC (hydration coefficient): the ratio of the weight of blanched seed to dry seed
[5] WDC (washed drained weight coefficient): the ratio of the weight of rinsed and drained canned seed to the blanched seed weight
[6] Texture is measured on canned beans as force (kg) required to crush the sample
[7] Appearance the canned bean sample on a scale from 1-5 (1=unacceptable, 5=exceptional)
[8] Eastern locations refer to Bay Co. in 2020 and 2021, Western locations include Tuscola Co. in 2020 and Huron in 2021
* Means followed by the same letter are not significantly different ($\alpha \leq 0.05$)

Table 3. Black Bean ANOVA Table for phenotypic traits based on the factors of variety, location, and the interaction between factors.

Measurement	**Factor 1 (Variety)**	**Factor 2 (Location)**	**Interaction (A*B)**
Hydration coefficient (HC)	0.001	0.28	0.40
Washed drained weight coefficient (WDW)	0.006	0.004	0.19
Texture	0.01	0.62	0.003
Color (Visual)	<0.001	0.006	<0.001
Appearance	<0.001	0.006	0.04
L*	<0.001	0.11	0.68
a*	<0.001	0.30	0.15
b*	<0.001	0.78	0.14

Table 4. Pinto bean ANOVA table for phenotypic traits based on the factors of variety, location, and the interaction between factors.

Measurement	**Factor 1 (Variety)**	**Factor 2 (Location)**	**Interaction (A*B)**
Hydration coefficient	<0.001	0.30	0.04
Washed Drained Weight Coefficient (WDW)	<0.001	0.69	0.26
Texture	0.21	0.47	0.07
Appearance	0.05	0.59	0.39

Bayer Irrigated Dry Bean Fungicide Trials

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Locations: Montcalm Research Center	**GPA:** 22
Planting Date: June 8, 2022	**PSI:** 60
Replicated: 4 times	**Nozzle:** TP8002VS
Design: RCBD	**Timing:** R1 (A) & R3 (B)
Variety: Viper Small Red	**Row width:** 20-inch
Population: 120,000 seeds/A	**Treated Plot Size:** 6.6' x 20'
Harvest Date: October 4, 2023	**Application date**: July 25 (A) & August 2 (B)

Table 1. Dry bean fungicide treatments, application timing, test weight and dry bean yield.

#	Treatments	Application Timing	Severity	% infection	Test Weight (lb./bu)	Yield [ab]
1	Untreated	-	4.0	81	61.5	2778
2	Propulse (6 fl oz)	AB	3.5	70	63.5	3245
3	Propulse (8 fl oz)	AB	4.0	96	64.0	3620
4	Propulse (10.3 fl oz)	AB	3.5	77	64.2	3404
5	Delaro (12 fl oz) Fb. Propulse (8 fl oz)	AB	4.3	75	62.9	2842
6	Delaro (12 fl oz) + Luna Privlege (2 fl oz) Fb. Propulse (8 fl oz)	AB	4.3	59	57.7	2784
		Mean:	3.9	76%	62.3	3112
		LSD:	2.4	27	4.3	472
		Cv:	50%	29%	5.2%	15.1%

[a] Means within the same column with different letters are not significantly different from each other ($\alpha \leq 0.05$).
[b] Severity is evaluated 1 (very little infection in upper stems) – 9 (pods and stems on the soil surface)
[c] Yield is in pounds per acres obtained by direct harvest, adjusted to 18% moisture.

Summary: An irrigated white mold trial was established at the Montcalm Research Center (MRC) near Entrican, MI in 2022. Disease pressure averaged 76% across all treatments, however, disease was somewhat erratic in nature and not uniform across the trial design. In addition high temperatures in 2022 kept the severity of disease low, averaging only a 4.0 in the untreated on a scale of 1-9 in 2022. Treatments were made at two separate timings: (A) R1 and (B) 8 d. after R1. While not significant the sequential application of Propulse produced the highest numerical yield in 2022, producing 3620 lb/A when 8 fl oz of Propulse was applied twice (AB). This was also the case in 2021 with the exception of rate, in 2021 the 10.3 fl oz rate numerically outperformed the 8 fl oz rate. Results do also indicate the limitations of current fungicide products for the suppression of white mold. The Montcalm Research Center has a 5-year yield history of well over 3,000 lb. per acre in these trials that receive excellent fertility and additional irrigation. However, with this year's environmental conditions white mold disease limited dry bean yield even when multiple applications of the best available product were made on a susceptible variety (Viper small reds).

Non-Irrigated Dry Bean Fungicide Trials

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Locations: Pigeon, MI & Richville, MI	**GPA:** 22
Planting Date: June 8 & May 31	**PSI:** 60
Replicated: 4 times	**Nozzle:** TP8002VS
Design: RCBD	**Timing (A):** R1
Variety: Viper Small Red & Bounty Navy	**Row width:** 20-inch
Population: 120,000 seeds/A	**Treated Plot Size:** 6.6' x 20'
Harvest Date: September 9, 2023	**Application A** (R1): July 20

Table 1. Pigeon, MI dry bean fungicide treatments, application timing, test weight and dry bean yield (Viper Small Reds).

#	Treatments	Application Timing	Test Weight (lb./bu)	Yield [ab]
1	Untreated	-	60.1 a	2574
2	Propulse (10.3 fl oz)	A	60.4 a	2779
3	Propulse (10.3 fl oz) + Quadris (5 fl oz)	A	57.4 a	2538
4	Topsin M (30 fl oz)	A	60.7 a	2936
5	Priaxor (8 fl oz)	A	60.3 a	2667
6	Priaxor (8 fl oz) + Propulse (10.3 fl oz)	A	60.7 a	2638
7	Miravis Prime (13.4 fl oz)	A	54.1 b	2361
8	Badge (16 fl oz) + Propulse (10.3 fl oz)	A	57.2 a	2416
9	Omega (8 fl oz)	A	61.8 a	3039
		Mean:	59.1	2661
		LSD:	2.5	403
		Cv:	3.5%	12.5%

[a] Means within the same column with different letters are significantly different from each other ($\alpha \leq 0.05$).
[b] Yield is in pounds per acres obtained by direct harvest, adjusted to 18% moisture.

**Results continued on the next page*

Non-Irrigated Dry Bean Fungicide Trials

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Table 2. Richville, MI dry bean fungicide treatments, application timing, Test weight and dry bean yield (HMS Bounty Navy Bean).

#	Treatments	Application Timing	Test Weight (lb./bu)	Yield [ab]
1	Untreated	-	50.6	2731
2	Propulse (10.3 fl oz)	A	56.6	3148
3	Endura (8 oz)	A	60.5	3343
4	Omega (8 fl oz)	A	50.5	3342
5	Topsin M (20 fl oz)	A	58.6	2913
6	Topsin M (40 fl oz)	A	57.2	3550
7	Priaxor (8 fl oz)	A	61.4	3390
8	Priaxor (8 fl oz) + Propulse (10.3 fl oz)	A	62.2	3779
9	Badge (32 fl oz)	A	59.3	3227
10	Delaro (12 fl oz)	A	59.0	3381
		Mean:	59.1	3280
		LSD:	2.5	831
		Cv:	3.5%	21.0%

Summary: Two fungicide trials were established in the Thumb and Saginaw valley in 2022 with the goal of testing commercial fungicide products under average to low disease pressure. Both locations were on clay loam soil types and were non- irrigated. All applications were made utilizing a CO2 sprayer at 60 PSI calibrated to 22 GPA. Overall, white mold infection in the untreated control was less than 10% at both locations utilized in 2022. Rainfall from planting until R1 (application timing) was below 1" at both locations in the season of testing. A single application was made at R1 at both locations. Due to lack of disease development, and environmental conditions (hot and dry without canopy closure) second applications were not made at either location in 2022. Dry bean yield did not significantly respond to fungicide applications in either location in 2022. Test weight was not significantly impacted at either location with the exception of Miravis Prime indicating a slight reduction when compared to the untreated (Table 1.). However, this effect should be confirmed in future season with lower levels of crop stress at application. While this yield data is contrary to 2020 and 2021 research findings (signifigant yield increases were documented in 2020 and 2021) high levels of drought and trial variability as a response may have confounded the significance of this year's trial. Continued analysis of fungicide programs and tank-mixes should continue in 2023.

Gowan Irrigated Dry Bean Fungicide Trial

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Locations: Montcalm Research Center	**GPA:** 22
Planting Date: June 8, 2022	**PSI:** 60
Replicated: 4 times	**Nozzle:** TP8002VS
Design: RCBD	**Timing:** R1 (A) & R3 (B)
Variety: Viper Small Red	**Row width:** 20-inch
Population: 120,000 seeds/A	**Treated Plot Size:** 6.6' x 20'
Harvest Date: October 4, 2022	**Application date**: July 25 (A) & August 2 (B)

Table 1. Dry bean fungicide treatments, application timing, test weight and dry bean yield.

#	Treatments	Application Timing	Severity	% infection	Test Weight (lb./bu)	Yield [ab]
1	Untreated	-	5.3 ab	83 ab	58.0	2319 b-d
2	Domark (6.4 fl oz) + NIS (0.25%)	AB	4.5 a-c	91 a	52.8	2190 cd
3	Domark (6.4 fl oz) + Badge (32 fl oz)	AB	3.5 a-c	89 a	51.2	2076 d
4	Affiance (10 fl oz) + NIS (0.25%)	AB	5.5 a	98 a	48.0	1995 d
5	Affiance (10 fl oz) + Badge (32 fl oz)	AB	4.5 a-c	93 a	53.2	2204 cd
6	Affiance (16 fl oz) + NIS (0.25%)	AB	5.3 ab	90 a	50.7	2167 cd
7	Affiance (16 fl oz) + Badge (32 fl oz)	AB	3.5 a-c	92 a	55.4	2292 cd
8	Endura (8 oz)	AB	2.5 c	69 ab	55.0	2471 a-d
9	Endura (8 oz) + Badge (32 fl oz)	AB	3.0 bc	84 ab	62.7	3205 ab
10	Topsin (30 fl oz) + NIS (0.25%)	AB	4 a-c	76 ab	63.0	3075 a-c
11	Topsin (30 fl oz) + Badge (32 fl oz)	AB	3 bc	51 b	63.1	3137 a-c
12	Propulse (10.3 fl oz) + NIS (0.25%)	AB	2.5 c	68 ab	63.4	3320 a
13	Propulse (10.3 fl oz)	AB	2.5 c	58 ab	63.5	2834 a-d
14	Omega (8 fl oz)	AB	4.0 ac	86 ab	60.2	2969 a-d
		Mean:	3.8	81	57.2	2590
		LSD:	1.2	21	8.6	539
		Cv:	27	22	12.7	17.8%

[a] Means within the same column with different letters are not significantly different from each other ($\alpha \leq 0.05$).
[b] Severity is evaluated 1 (very little infection in upper stems) – 9 (pods and stems on the soil surface)
[c] Yield is in pounds per acre obtained by direct harvest, adjusted to 18% moisture.

Summary: An irrigated white mold trial was established at the Montcalm Research Center (MRC) near Entrican, MI in 2022. Disease pressure averaged 81% across all treatments and was more uniform in nature than other white mold trials in 2022.

2022 'Headsup' Seed Treatment Trial

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Introduction

In 2022, Michigan State University researchers and Michigan dry bean producers tested 161 lines from 12 market classes of dry beans. The trial plots (Table 1) were placed in six locations across five Michigan counties: Bay, Huron, Montcalm, Sanilac, and Tuscola (two sites).

This report summarizes the results of the HeadsUp seed treatment trials included at four of the total locations.

Table 1. 2022 research trial conditions: The locations, grower co-operators, planting dates, nitrogen application rates and methods, total accumulated growing degree days (GDD), and total precipitation.

County	Co-operator	Planting Date	Nitrogen Rate *(Lbs./A)*	Nitrogen Application Method	Total GDD [a]	Total Precipitation *(Inches)*
Bay	Schindler Farms	June 15	50	Broadcast	1,847	11.37"
Huron	Richmond Brothers	June 8	50	2x2	1,868	5.37"
Sanilac	Stoutenburg Farms	June 3	50	Broadcast + 2x2	1,998	8.00"
Tuscola	Rayl Farms	June 2	50	2x2	2,108	9.52"

Methods

Dry beans were seeded in four-row plots that measured 6.6' wide by 20' long, with 20" rows. Each entry was replicated four times. All trial plots were designed as randomized complete blocks (RCB).

Trials received industry standard seed treatments, fertilization, and weed control applications at labeled rates. White mold fungicides were not applied to any location. The absence of fungicide allowed the evaluation of each entry's natural tolerance for or avoidance of white mold.

Yield data was obtained by direct harvest. Following harvest, samples were cleaned, weighed, and moisture tested.

Table 2. Soil test information from the six 2022 performance trial locations, including the percentage of organic matter, soil type, and soil pH. All macro- and micronutrients were sufficient for dry bean production.

Location	Percentage of Organic Matter	Soil Type	Soil pH
Bay	2.3	Loam	7.3
Huron	2.2	Loam	7.6
Sanilac	3.5	Loam	7.2
Tuscola	2.5	Sandy Loam	7.1

2022 'Headsup' Seed Treatment Trial

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Results

Tables 3 provides agronomic information including white mold tolerance. The percentage of white mold infection on each replication was calculated in Bay, and Tuscola counties:

(number of infected plants ÷ total plants per stand) × 100 = percentage of infection

The table also present each entry's yield results in pounds per acre (Lbs./A) adjusted to 18% moisture.

The combined average yield for each entry across all sites in 2022 is also included. The last three rows of the agronomic and yield results tables list the trial average (mean), least significant difference (LSD), and coefficient of variation (CV), respectively, for the data in each column.

The entry with the **highest** value in each yield column is followed by two asterisks (**). Any yields listed in the same column that are not significantly different from the highest yield are noted with one asterisk. Conversely, the entry with the **lowest** white mold infection percentage is also noted with two asterisks, and any entries in that column that are not significantly different from the lowest infection percentage are marked with one asterisk. This means that if two entries in the same column are followed by either one or two asterisks, the difference in values between the entries is not statistically significant.

Table 3. Headsup Seed Treatment agronomic and yield results.

ENTRY	Bay Co. White Mold Infection *(%)*	Tuscola Co. White Mold Infection *(%)*	Two Location Average White Mold Infection *(%)*	Bay *(Lbs./A)*	Huron *(Lbs./A)*	Sanilac *(Lbs./A)*	Tuscola *(Lbs./A)*	1-year avg. *(Lbs./A)*
Cruiser Seed Treatment	13	70	46	3076	2311	3315	2909	2973
Cruiser Seed Treatment + HeadsUp (0.5oz cwt^{-1})	33	66	50	3559*	2509	3189	3211	3117
Cruiser Seed Treatment Fb. HeadsUp (1oz cwt^{-1})	27	65	46	3802**	2493	3445	3394	3272
MEAN:	25	67	47	3479	2439	3062	3172	3120
LSD$_{(0.05)}$:	NS	NS	NS	298	NS	NS	NS	NS
CV:	44.1%	9.8%	54.2%	6.0%	14.5%	7.6%	12.7%	17.0%

Note. The highest yielding entry in each column is marked with two asterisks. Any entries in the column with yields that were not statistically different from the highest yielding entry are marked with one asterisk. Variety used was 'Black Bear' black bean sourced from cooperative elevator company.

Helm Agro Irrigated Dry Bean Fungicide Trials

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Locations: Montcalm Research Center	**GPA:** 22
Planting Date: June 8, 2022	**PSI:** 60
Replicated: 4 times	**Nozzle:** TP8002VS
Design: RCBD	**Timing:** PRE (A), R1 (B), & R3 (C)
Variety: Viper Small Red	**Row width:** 20-inch
Population: 120,000 seeds/A	**Treated Plot Size:** 6.6' x 20'
Harvest Date: October 4, 2022	**Application date**: June 8th (A), July 25th (B), & August 2nd (B)

Table 1. Dry bean fungicide treatments, application timing, disease severity, test weight and dry bean yield.

#	Treatments	Application Timing	Severity	% Infection	Test Weight (lb./bu)	Yield [ab]
1	Untreated	-	5.3	94	50.7	2089
2	Soilset (16 fl oz) (A)	A	4.8	72	48.3	2025
3	Soilset (16 fl oz) (A) Fb. Agromos (16 fl oz) (B)	AB	4.3	77	58.0	2407
4	Soilset (16 fl oz) (A) Fb. Agromos (16 fl oz) (BC)	ABC	4.8	76	55.8	2293
5	Soilset (16 fl oz) (A) Fb. Agromos (16 fl oz) (B) Fb. Propulse (10.3 fl oz) (C)	ABC	4.3	82	54.1	2518
6	Soilset (16 fl oz) (A) Fb. Propulse (10.3 fl oz) (BC)	ABC	4.5	77	55.2	2351
		Mean:	4.3	80	53	2280
		LSD:	2.7	34	13	668
		Cv:	48%	35%	53%	23%

[a] Means within the same column with different letters are not significantly different from each other ($\alpha \leq 0.05$).
[b] Severity is evaluated 1 (very little infection in upper stems) – 9 (pods and stems on the soil surface)
[c] Yield is in pounds per acre obtained by direct harvest, adjusted to 18% moisture.

Summary: An irrigated white mold trial was established at the Montcalm Research Center (MRC) near Entrican, MI in 2022. Disease pressure averaged 80% across all treatments. However, disease severity followed a highly erratic pattern of severity. Due to this erratic nature of severity in 2022, no significant differences were observed for any measurable across all treatments tested. While this trial demonstrated crop safety (no phytotoxicity) for both biological products that had not been previously tested (Soilset and Agromos) significant conclusions about plant stress responses, or disease suppression cannot be drawn from this trial in 2022.

2022 Montcalm County Kidney Bean Foliar Fertilizer Trial

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Locations: Lakeview, MI	**GPA:** 22
Planting Date: June 10, 2022	**PSI:** 60
Replicated: 4 times	**Nozzle:** TP8002VS
Design: RCBD	**Timing:** R1 (A)
Variety: Cabernet Dark Red Kidney	**Row width:** 20-inch
Population: 100,000 seeds/A	**Treated Plot Size:** 6.6' x 20'
Harvest Date: October 3, 2022	**Application date**: July 18th

Table 1. Dry bean foliar fertilizer treatments, application timing, test weight and dry bean yield.

#	Treatments	Application Timing	Yield [ab]
1	Untreated	-	2944 a
2	ZMB Plus (16 fl oz)	A	2781 a
3	ENC Flex (16 fl oz)	A	2975 a
4	Surecrop "Dry Bean Mix" (64 fl oz)	A	2924 a
		Mean:	2906
		LSD:	135
		Cv:	3.5%

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

Summary: In 2022 a foliar fertilizer trial was established at *Rader Farms* near Lakeview Michigan. The variety 'Cabernet' Dark Red Kidney was planted at a population of 100,000 seeds per acre in 20-inch rows. Standard management was followed for PPI and POST emergence weed control. At R1 three treatments were individually sprayed (each with four replications). At this time a blanket application of Priaxor was also made across all treatments at a rate of 6 fl. oz. per acre for the suppression of anthracnose and white mold. Trial quality was excellent and had very low levels of variability (Coefficient of variance=3.5%). Plots were pulled with a rod puller on the morning of October 3rd and thrashed that same afternoon. Results indicate there was no significant response to any foliar fertilizer product tested in 2022. However, it is important to note that no yield increases, nor decreases were documented. Previous research with foliar fertilizer products on kidney and cranberry beans applied in the reproductive stages of development can induce a negative crop response (Followed by yield reductions). This response was more common when higher rates were used (16 vs. 32 fl oz per acre) of products like ZMB Plus and ENC Flex in separate trials.

2022 Montcalm County Kidney Bean Foliar Fungicide Trial

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Locations: Lakeview, MI	**GPA:** 22
Planting Date: June 10, 2022	**PSI:** 60
Replicated: 4 times	**Nozzle:** TP8002VS
Design: RCBD	**Timing:** R1 (A)
Variety: Beluga White Kidney	**Row width:** 20-inch
Population: 100,000 seeds/A	**Treated Plot Size:** 6.6' x 20'
Harvest Date: October 3, 2022	**Application date**: July 18th

Table 1. Dry bean foliar fungicide treatments, application timing, lodging rating and dry bean yield.

#	Treatments	Application Timing	Lodging	Yield [ab]
1	Priaxor (6 fl oz) (B)	B	2.3	2517
2	Priaxor (6 fl oz) AB	AB	2.0	2618
3	Propulse (10.3 fl oz) (A) Fb. Priaxor (6 fl oz) (B)	AB	2.3	2538
4	Omega (8 fl oz) (A) Fb. Priaxor (6 fl oz) (B)	AB	2.3	2834
5	Delaro (12 fl oz) (A) Fb. Priaxor (6 fl oz) (B)	AB	1.3	2679
		Mean:	2.0	2640
		LSD:	-	346
		Cv:	-	10.4%

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

Summary: In 2022 a foliar fungicide trial was established at Rader Farms near Lakeview Michigan. The variety 'Beluga' White Kidney was planted at a population of 100,000 seeds per acre in 20-inch rows. Standard management was followed for PPI and POST emergence weed control. At R1 5 treatments were individually sprayed (each with four replications). One week later a blanket application of Priaxor was also made across all treatments at a rate of 6 fl. oz. per acre for the suppression of anthracnose and white mold. While Beluga is genetically resistant to the endemic race of anthracnose, at the time of application race was not known and this trial was included in the application as a preventive measure. This somewhat confounds the trial as a true untreated no longer existed. However, trial quality was very good and serves as a comparison of fungicide programs relative to each other on kidney beans, a growth type not often included in this type of testing. Plots were pulled with a rod puller on the morning of October 3rd and thrashed that same afternoon. Results indicate there was no significant difference in yield between fungicide programs in 2022. One note of interest was low levels of visible phytotoxicity (<10%) from Delaro (12 fl oz) applications. It is hypothesized that this is correlated with the numerically lower lodging scores (1.3 vs mean 2.0) for this treatment as vegetative growth was stunted.

Dry Bean Response to In-Furrow Applications of Propulse

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Location: SVREC (June 15, 2022)	**Treated Plot Size:** 6.6' x 250'
Replicated: 4 times	**GPA:** 9.6
Design: RCBD	**PSI:** 10
Variety: Adams Black Bean	**Application Timing:** 'A' at planting
Population: 105,000 seeds/A	**Nozzle:** TP8002VS
	Row Width: 20-inch

Table 1. Treatments, application timing, stand counts, and dry bean yield.

#	Treatment	Application Timing	Stand Count/A	Yield *
			105 DAP	
1	Untreated	-	45526	2755
2	Propulse 6 fl. oz./A	A	44476	2614
3	Propulse 8 fl. oz./A	A	40803	2581
4	Propulse 10 fl. oz./A	A	43746	2701

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

Summary: A trial was established in 2022 to test dry bean tolerance to in-furrow applications of multiple rates of Propulse fungicide. Applications were made from 6- 10 fl. oz. per acre directly into the seed furrow at planting. This trial was not inoculated with any specific root rot pathogens and natural disease pressure was not great enough for evaluation of root rot. Seed for all treatments was treated with a standard Cruiser Max Vibrance (3.22 fl. oz. per 100 Lb. of seed) seed treatment prior to planting. When data was analyzed neither evaluation of stand count nor yield were significantly impacted by fungicide application when compared to the untreated control ($P \leq 0.05$). While this trial demonstrated an acceptable level of crop safety at the rates tested, additional research is required to better understand the impact Propulse may have on dry bean root diseases.

Dry Bean Response to In-Furrow Applications of Fertilizer When Compared to Foliar Programs

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Location: SVREC	**Treated Plot Size:** 6.6' x 250'
Planting Date: June 15, 2022	**Applications:** • **'A'** at planting **PSI:** 10 **GPA:** 9.6 • **'B'** V3 growth stage **PSI:** 60 **GPA:** 22
Replicated: 4 times	
Design: RCBD	
Variety: Adams Black Bean	**Nitrogen:** 50 lb./A applied PPI
Population: 105,000 seeds/A	**Row Width:** 20-inch

Table 1. Treatments, application timing, and dry bean yield.

#	Treatment	Application Timing	Yield [b]
1	Untreated	-	2990 a
2	SureCrop In- Furrow (3.0 gal/A)	A	2740 a
3	SureCrop Foliar (2 qt/A)	B	2860 a

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

Summary: A three-treatment trial was established in 2022 to test dry beans yield response to SureCrop fertilizer products. Black beans were seeded in 20-inch rows on June 15th at the Saginaw Valley Research and Extension Center. Plot length was greatly extended to ensure uniform application of in-furrow products at commercial planting speeds (>4 MPH) and gallons per acre (<10 GPA). At the time of planting 3.0 gallons per acre of SureCrop In-Furrow dry bean mix was applied in a 4" band directly over the open furrow prior to closing. This was the only fertilizer treatment applied to treatment number two. Twenty eight days after planting treatment three was applied at the V3 growth stage. This treatment consisted of 2 quarts per acre of SureCrop foliar dry bean mix, this was the only additional fertilizer product applied to treatment three in 2022. Yield was obtained on October 1st by direct harvest. After analysis it was determined that no differences in dry bean yield were documented in 2022 when compared to the untreated control ($P \leq 0.05$).

Navy Bean Response to Biological Stimulants

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Location: Pigeon, MI	**Treated Plot Size:** 6.6' x 20'
Planting Date: June 8, 2022	**Applications:** • **A** Seed Treatment • **B** V3 growth stage
Replicated: 4 times	
Design: RCBD	
Variety: HMS Bounty	**Nitrogen:** 15 GPA 28-0-0 in 2x2
Population: 105,000 seeds/A	**Row Width:** 20-inch

Table 1. Treatments, application timing, and dry bean yield.

#	Treatment	Application Timing	Yield [b]
1	Untreated	-	2705 a
2	Envita (13 oz per unit)	A	2581 a
3	Pod FX (1 oz per unit)	A	2994 a
4	Envita (10 oz per acre)	B	2573 a
		LSD:	665
		CV:	18.9%

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

Summary: A four-treatment trial was established in 2022 to test dry beans yield response to both Envita and Pod Fx biological products. Treatments 2 and 3 were applied as a seed treatment over the commercial standard 'CruiserMax Vibrance' seed treatment (3.22 fl. oz. per 100 Lb. of seed). At the time of planting navy beans were seeded in 20-inch rows on June 8th at *Richmond Brothers Farms* near Pigeon, MI. Treatment 4 was applied foliar at V3 growth stage on July 6th 2022. The trial location was subject to exceedingly dry conditions throughout the duration of the growing season. Later season rainfall greatly aided in pod fill, but trial quality had already been negatively impacted (18.9% CV). Yield was taken by direct harvest. After analysis it was determined that no differences in dry bean yield were documented in 2022 when compared to the untreated control ($P \leq 0.1$).

The Interaction Between Dry Bean Variety and Response to Fungicide

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Introduction:
In recent years there has been increasing interest and understanding of how current commercial dry bean varieties may be better adapted for certain production conditions than others. A good example of this is selecting varieties with a higher tolerance for white mold for fields that have a history of mold issues. While this is a good start to the evolution of variety selection it is also important to understand how these varieties may respond differently to inputs or management. Otherwise known as: genetics * environment * management= yield. To research this question six commercial dry bean varieties (5 black and 1 navy) were selected and placed into testing at the 'Answer Plot' location hosted by the Cooperative Elevator Company near Sebewaing, MI.

Methods:
Dry beans were seeded in four-row plots that measured 6.6' wide by 50' long, with 20" rows on the evening of June 22nd. Planting population was 130,000 seeds per acre for all entries. 50 lb. of nitrogen was applied at plating utilizing 2x2 placement of 28-0-0 fertilizer. Each entry was replicated **eighteen times** in a split plot design. This trial was highly replicated in effort to statistically separate small differences between varieties tested. Trials received industry standard seed treatments, fertilization, and weed control applications at labeled rates. Fungicide was applied to half of the replications for each entry. The product used was Propulse at 10.3 fl oz. per acre at R1. Yield data was obtained by direct harvest. Following harvest, samples were cleaned, weighed, and moisture tested. All yield data is adjusted to a standard 18% moisture for standardization.

Results:
Trial quality was excellent in 2022. Late season rains resulted in good vegetative growth and pod fill. White mold infection averaged 60% in plots that were **not** sprayed with fungicide. Both main plot and subplot effects were significant in this testing. **Fungicide:** When averaged across all entries the plots that were sprayed with fungicide yielded 161 lb./A more than the untreated ($P \leq 0.05$) (36.3 cwt vs. 37.9 cwt.). Due to the severity of disease that resulted in this location a second application of fungicide could have increased this yield difference further than the 1.6 cwt observed. **Variety:** When averaged across fungicide treatments the varieties: Spectre (40.0 cwt), Adams (37.2 cwt), Nimbus (36.4 cwt), HMS Bounty (Navy) (37.2 cwt), and Black bear (37.6) significantly out yielded the variety Black Beard (34.1 cwt) ($P<0.05$). However, results indicate that there was an interaction between the two factors of variety and fungicide. This means that at least one variety responded differently than the rest to the added input of fungicide. **Fungicide * Variety:** Results presented in ***Table 1.*** indicate that magnitude of response was greater for Spectre than other varieties tested ($P<0.05$). Spectre increased yield by 529 lb/ acre when fungicide was applied, compared to: Black Beard (188 lb.), Adams (143 lb.), Nimbus (225 lb.), HMS Bounty (-51 lb.), and Black Bear (76 lb.). Testing will be expanded in 2023 to include more commercial varieties and market classes.

Table 1. Interaction of Factor 1 and Factor 2 (Variety * Fungicide)

Variety	Propulse (10.3 fl oz)	Untreated	Response
	Lb. Per Acre[ab]		Lb. Per Acre
Black Beard	3514 bc	3325 c	188
Spectre	4255 a	3725 bc	529
Adams	3799 b	3656 bc	143
Nimbus	3712 bc	3489 bc	225
HMS Bounty	3694 bc	3746 b	-51
Black Bear	3805 b	3728 bc	76
Mean:	3796	3635	161

[a] Means within the table with different letters are not significantly different from each other ($\alpha \leq 0.05$).
[b] Yield is in pounds per acre obtained by direct harvest, adjusted to 18% moisture.

Developing an imaging pipeline to estimate plant maturity to improve the accuracy of selecting and developing dry bean cultivars with appropriate maturity

Francisco Gomez, Leonardo Volpato, and Evan Wright

The Michigan State University (MSU) dry bean breeding program has collected RGB-images using unmanned aerial system (UAS) in field trials across locations (Huron and Tuscola counties) for black and navy bean market classes to develop a high-throughput phenotyping pipeline to estimate dry bean maturity. Trials were planted in an α-lattice design with four replicates (complete blocks) and incomplete blocks (Iblock), depending on the number of entries including commercial checks using four-row plots. Prior to image collection, a set of ground control points (GCPs) were placed and surveyed across the experimental field for georeferenced correction of the image. All flights were conducted within two hours of solar noon to limit shadow effects. UAS-images were collected two times per week prior to maturity up until physiological maturity. Ground truth data was collected for two weeks in the end of August and the beginning of September to estimate a wide range of maturity dates. Ground-truth visual RM date were taken by trained dry bean students and technicians visiting plots and manually observing and revisiting plots as they matured, eventually assigning a date of maturity to each plot. The ground-truth data were rating as soon as the earliest maturing varieties in each location began to senesce. A plot was determined to be mature when approximately 95% of pods exhibited their mature color (Fehr & Caviness, 1977). Plots were visited twice a week, or more, and maturity dates were interpolated when it was clear a plot reached maturity in between site visits. The date of plot maturity was expressed as the number of days after July 31 corrected by the planting date for all environments. **Figure 1** shows ground-truth data for relative maturity across multiple locations from 2021-2022. Processing of aerial images using an RGB sensor will follow four major steps to develop a high throughput imaging pipeline. The four major steps in the pipeline will be (1) UAS image collection, (2) orthomosaic generation, (3) image processing, and (4) biometric analysis. The Pix4D Mapper® software will be used for the orthomosaics generation. Georeferencing using GCPs will be done in Pix4D software to improve the three-dimensional (3D) point cloud accuracy. R and Python statistical software will be used to create the plot boundary delimitation (shapefiles) of the plots in the fields, and GIS software - ArcGIS - will be used for shapefile adjustment. Custom image processing algorithms using R programming language will be used to extract features as well as data mining (**Figure 2**).

Results demonstrate that utilizing machine learning methods we are able to estimate RM accurately in dry bean but can vary by market class. We expect to have a publication for this work in 2023 as well as an open source tool to apply in dry bean breeding program to estimate RM.

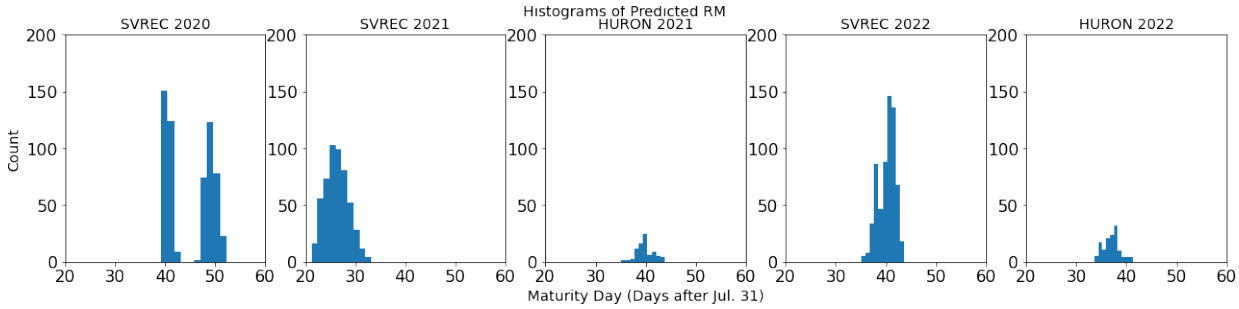

Figure 1. Histogram of relative maturity days for 5 environments from 2021-2022. Relatively maturity as days since July 31 corrected by the planting date.

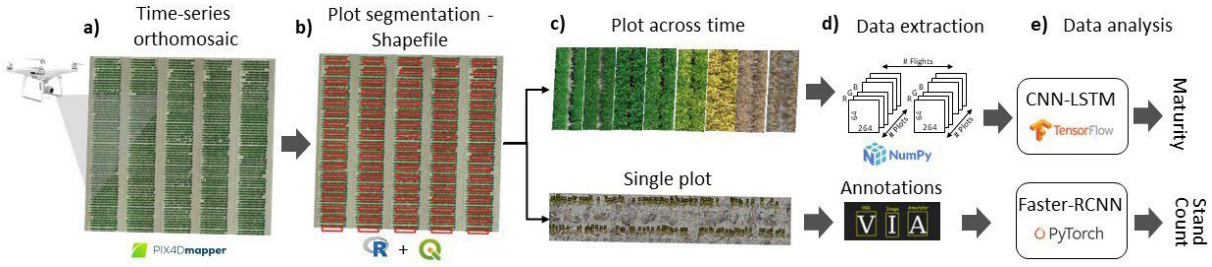

Figure 2. Illustration of the general HTP pipeline for RM and SC estimations

2022 BLACK AND NAVY BEAN YIELD TRIALS

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Plant, Soil and Microbial Sciences

Expt. 2201: Standard Black Bean Yield Trial

This 36-entry trial included standard commercial black bean varieties and advanced breeding lines. Yields ranged from 18.0 to 28.6 cwt/acre with a test mean of 23.8 cwt/acre. Variability was moderate in this test, (CV=10.3%) and the LSD was 2.9 cwt/acre. Five entries significantly out yielded the test mean which included B20536 and B21710 for the second consecutive year. Adams (26.6cwt) and Zenith (26.1 cwt) were the top yielding varieties. Zenith continues to show stable and competitive yield potential in recent years. Given recent concerns about canning quality in the industry, this variety should not be overlooked by growers seeking black beans with good color retention for the canning market. In contrast, Nimbus (21.7 cwt) ranked below mean, and Black Beard (18.0 cwt) was the lowest yielding entry. While these varieties produce competitive yields for growers and in on-farm performance trials, they do not serve as useful checks in these breeding trials due to complete susceptibility to CBB which reduces their yield. Zorro (19.8 cwt) ranked unusually low this year as well. Several newer B217xx lines matched or exceeded the yield of Adams, demonstrating continued breeding progress. B19344 which has excellent canning quality similar to Zenith, ranked with Nimbus in this trial. It has produced ~35cwt 3-year average yield in on-farm performance trials suggesting it should be considered for release in response to the lack of canning quality among newer varieties currently in the marketplace. All entries will be canned to evaluate color retention and quality to inform decisions on advancement to 2023 testing.

Expt. 2202: Standard Navy Bean Yield Trial

This 30-entry trial included standard commercial navy bean varieties, and advanced lines from the MSU breeding program. Yields ranged from 15.6 to 28.0 cwt/acre with a mean of 23.9 cwt/acre. Variability in this trial was well controlled (CV= 9.6%) and the LSD needed for significance was 2.7 cwt/acre. Four breeding lines significantly outyielded the test mean, and overall navy yields were equivalent compared to those of black beans. Three of these entries were newer N215xx lines that yielded well in their first year of testing in 2021 and continued to look promising in 2022. The persistent yield potential of N19277, N19246, and N18105 which have ranked within the top ten entries consistently over the past four years despite contrasting seasons is noteworthy. N19246 appears to offer the best overall agronomic characteristics, with good upright architecture and efficient dry down at 98 days maturity. Given continued interest in enhancing sustainability and the current conversations regarding potential need for reduced desiccant use to satisfy consumer perception of environmental impacts of bean production, this line merits consideration for release. Commercial checks in this trial all ranked below the trial mean. As discussed above for newer black beans varieties, newer navies Liberty and HMS Bounty produced lower yields than expected due to complete susceptibility to CBB infection that reduced yield. The older MSU variety Alpena has proved a more stable check for these conditions, although it continues to move down in rank as newer breeding lines continue to add genetic yield gain over time. Canning tests will be conducted on all entries before being considered for advance to future trials.

EXPERIMENT 2201 STANDARD BLACK BEAN YIELD TRIAL							PLANTED: 6/1/22				
NAME	PEDIGREE	ENTRY	YIELD CWT /ACRE	100 SEED WT. (g)	DAYS TO FLOWER	DAYS TO MATURITY	LODGING (1-5)	HEIGHT (cm)	DES. SCORE	CBB (1-5)	Dry Down (1-5)
B21713	B16501/B16504	29	28.6	25.5	47.3	100.8	2.5	45.8	4.3	1.0	2.8
B20536	B15430/B16504	1	27.7	24.0	49.0	100.5	2.0	49.3	5.8	1.0	2.0
B21710	B16501/B15430	24	27.5	23.2	47.8	100.3	1.8	46.8	5.0	1.0	2.0
B21715	B16501/B16504	33	27.2	22.9	47.8	100.0	1.5	43.0	4.3	1.5	1.8
B20542	B16501/B15430	18	27.0	25.1	47.3	99.0	1.0	39.5	4.5	1.0	1.5
B18504	Zenith//Alpena*/B09197, **ADAMS**	4	26.6	22.9	48.5	99.8	2.3	39.8	4.8	1.0	2.0
B20547	B16501/B16504	20	26.2	24.5	47.3	100.0	1.3	38.0	3.5	1.0	2.0
B10244	B04644/ZORRO, **ZENITH**	17	26.1	25.7	47.3	100.3	1.5	39.0	3.8	1.0	2.0
B20639	B17730/B15430	11	25.2	23.1	48.5	102.0	2.0	46.5	6.3	1.0	2.5
B21714	B16501/B16504	26	24.8	24.3	47.8	99.3	1.0	41.5	3.8	1.0	1.0
B20602	B16506/B16504	12	24.8	26.3	47.0	95.5	1.0	40.3	4.0	1.0	1.5
B19309	B15414/B16504	6	24.7	23.0	49.3	101.3	1.8	42.5	5.5	1.0	1.5
B20617	B17106/N14218	14	24.6	22.6	47.0	97.0	1.0	39.3	4.3	2.0	1.3
B20549	B16501/B16504	10	24.5	26.6	47.3	95.5	1.5	42.0	4.3	1.0	1.5
B21711	B16501/B15430	34	24.4	25.9	47.0	98.0	1.3	41.5	4.5	1.0	1.3
B20532	B15430/B16504	13	24.4	22.7	48.8	100.3	2.0	38.3	5.0	1.5	2.0
B21720	B16505/B16504	35	24.2	23.1	48.0	98.5	1.5	38.3	4.3	2.0	1.8
B19332	B16501/B15464	15	24.0	23.9	48.0	99.3	1.0	38.8	4.5	1.3	2.0
B20599	B16506/B15430	2	23.8	22.9	48.3	99.8	2.0	44.0	4.8	1.3	2.3
B21706	B15430/B16504	32	23.8	23.3	50.5	101.3	2.3	43.5	5.0	2.0	2.3
B19340	B16507/B15453	16	23.8	25.7	49.5	100.0	1.3	46.3	4.5	1.0	1.3
B21724	B17996/B17540	28	23.3	19.4	47.8	102.0	3.0	42.0	3.3	1.0	2.8
B21707	B15430/B16504	31	23.2	21.4	47.5	100.3	2.3	47.3	4.8	1.0	1.8
B21705	B14302/B15430	36	23.1	24.2	48.0	101.5	2.3	47.8	5.5	1.0	2.0
B21717	B16504/B17106	30	22.9	21.8	48.5	100.3	1.5	40.0	5.3	1.0	2.0
B20597	B16506/B15430	8	22.7	25.8	48.3	97.3	1.3	44.8	4.3	1.0	1.5
B20538	B15430/B16504	9	22.3	23.5	47.5	100.3	2.5	47.0	4.8	1.0	2.5
B19344	B16506/B16507	7	21.9	24.5	46.5	99.3	1.0	40.3	4.5	1.3	2.3
B20591	B16505/B16504	3	21.8	23.5	47.0	99.5	1.5	40.5	4.5	1.0	2.3
I21901	BL14500, **NIMBUS**	21	21.7	25.1	51.0	102.5	2.5	51.8	4.0	1.5	3.5
B21712	B16501/B16504	27	21.7	24.1	47.5	97.5	2.0	39.5	4.8	1.8	2.0
B21708	B15430/B16504	25	21.1	23.9	48.0	100.0	1.8	37.5	5.0	1.0	1.5
B20616	B17106/B17259	19	20.4	21.2	47.0	98.8	1.0	44.5	4.5	3.0	1.8
B04554	B00103*/X00822, **ZORRO**	23	19.8	21.8	47.8	101.0	3.0	44.8	3.8	1.0	3.5
B20590	B16505/B16504	5	18.5	22.7	47.8	99.3	1.5	38.3	4.3	3.8	2.5
I19703	BL14506, **BLACK BEARD**	22	18.0	25.0	48.5	102.5	2.3	53.5	5.0	1.8	3.8
MEAN (36)			32.1	20.6	44.1	85.5	1.7	46.8	4.4	3.6	3.4
LSD (.05)			3.6	0.9	0.4	2.6	0.8	5.3	0.7	0.4	0.3
CV%			9.5	3.6	0.7	1.8	29.1	9.6	8.9	7.4	7.3

EXPERIMENT 2202 STANDARD NAVY BEAN YIELD TRIAL									PLANTED: 6/1/22		
NAME	PEDIGREE	ENTRY	YIELD CWT /ACRE	100 SEED WT. (g)	DAYS TO FLOWER	DAYS TO MATURITY	LODGING (1-5)	HEIGHT (cm)	DES. SCORE	CBB (1-5)	Dry Down (1-5)
N19277	N14229/N14218	4	28.0	19.9	48.8	100.3	1.8	46.0	4.3	1.0	3.3
N21526	N17506/N14229	23	27.3	20.3	50.8	99.3	1.8	49.5	4.3	1.8	2.0
N21532	B16504/B11519	25	26.9	21.3	50.0	100.0	1.5	50.8	4.0	1.8	2.0
N21510	N15306/N14229	20	26.6	20.9	49.0	98.8	2.3	47.0	3.5	1.5	2.3
N19246	N15331/N16405	7	26.3	21.4	48.8	98.3	2.3	44.8	4.5	2.0	1.8
N18105	N13131/N14201	6	26.1	20.7	49.8	99.8	2.0	49.3	4.5	2.0	2.0
N20401	B16505/N17504	1	25.8	20.4	51.0	100.3	2.0	49.5	4.5	1.5	1.8
N20317	N14218/N17504	10	25.4	20.4	51.3	96.8	2.0	46.3	4.5	1.8	2.5
N21514	N15306/N17504	24	25.3	19.0	50.3	99.5	2.0	47.3	4.8	2.8	2.3
N21520	N17504/N14229	19	25.0	19.4	50.5	97.8	1.8	50.5	4.8	2.3	2.0
N22639	B19330/B19302	14	25.0	20.1	49.8	99.8	1.5	48.8	4.5	2.3	1.8
N20404	B16505/N17504	5	24.9	21.7	49.8	98.0	2.3	45.3	4.5	1.8	2.5
N21503	N14218/N17504	30	24.6	17.4	50.5	99.5	2.0	48.3	4.5	2.3	2.3
N19243	N15331/N16405	9	24.5	21.8	50.5	98.0	1.5	46.8	4.5	1.8	2.5
N21513	N15306/N16405	29	24.3	19.5	49.8	99.0	1.8	44.8	4.5	2.3	2.5
N21528	N17506/B15430	28	24.3	20.2	50.8	97.8	2.5	51.5	4.5	3.0	2.3
N21511	N15306/N15337	21	24.2	22.2	49.8	97.0	1.8	46.3	4.5	1.8	2.0
N20395	B16504/N17504	3	24.1	20.6	49.8	100.3	2.0	46.8	4.3	1.8	2.3
N21522	N17504/B15430	22	23.8	19.4	50.3	99.5	1.8	49.8	4.3	3.0	2.8
N19284	G14505/X16708	8	23.6	18.6	52.0	101.0	2.5	54.3	4.3	2.3	2.8
N21525	N17506/N14229	18	23.6	19.8	50.3	98.3	2.3	49.0	4.3	2.5	2.0
N21524	N17504/B17106	27	23.4	20.2	50.8	99.0	2.0	48.8	4.0	2.5	3.5
N11283	MEDALIST/N08003, **ALPENA**	15	22.5	19.5	48.5	100.0	2.0	49.8	4.0	1.8	2.5
I22001	**LIBERTY**	17	22.2	22.9	48.0	100.5	2.3	45.5	4.5	2.3	2.3
N20388	B15430/N14229	2	21.8	20.9	48.3	99.5	2.0	47.3	4.3	3.5	2.3
N20384	N14229/N17506	12	21.7	20.0	49.8	98.8	2.3	48.5	4.0	1.5	2.3
N21523	N17504/B15430	26	21.3	20.0	50.8	99.3	2.3	45.8	4.3	3.0	2.3
N18122	N15334/N15335	11	19.0	25.1	49.8	101.5	2.0	56.8	4.5	2.3	2.0
I21920	**HMS BOUNTY**	16	18.7	19.2	48.5	101.0	1.8	46.8	4.5	3.8	2.3
N18103	N13120/PR00806-81	13	15.6	22.5	49.8	101.3	2.8	44.8	3.8	1.8	3.0
MEAN (30)			23.9	20.5	49.9	99.3	2.0	48.2	4.3	2.2	2.3
LSD (.05)			2.7	0.8	1.0	1.0	0.7	3.9	0.4	0.7	1.0
CV%			9.6	3.4	1.7	0.8	30.9	6.9	8.5	28.9	35.1

Rhizoctonia Root Rot Screening Trial, East Lansing MI (2021 and 2022)

This 64-entry trial was conducted in collaboration with the Chilver's Lab at MSU to evaluate a range of diverse dry bean varieties and breeding lines for reaction to root rot specifically when inoculated with *Rhizoctonia solani*. Entries included commercial black, navy, pinto, and red lines as well as advanced MSU breeding lines. Lines in the trial were developed by MSU and Provita and planted in the 2021 and 2022 growing seasons. Entries were planted in two row plots under inoculated and non-inoculated treatments and plots were arranged in a randomized complete block design with four replicates. Stand count was collected one, three, and five weeks after planting. To evaluate the effect of the inoculation treatment we estimated the percentage of post-emergence damping-off as the difference between the first and last stand count, divided by the first stand count. Overall, results found that the inoculated plots had a higher percentage of post-emergence damping-off than the non-inoculated plots *Prob >|t| <0.001**. Lines that were inoculated had a higher percentage of post-emergence damping-off relative to non-inoculated as expected (Fig. 1). Significant differences were also found for post-emergence damping-off among genotypes (*P<0.0001**) (Fig. 2). The five lines with the highest post-emergence damping-off were B20536, Black Tails, B21708, N18103, and R20639. While the lines with the lowest post-emergence damping-off were P19707, G19611, Spectre, Merlin, and N20395. MSU breeding lines demonstrated to be tolerant to post-emergence damping-off caused by *Rhizoctonia solani* demonstrating the previous efforts to improve root rot tolerance in the small and medium-seeded types.

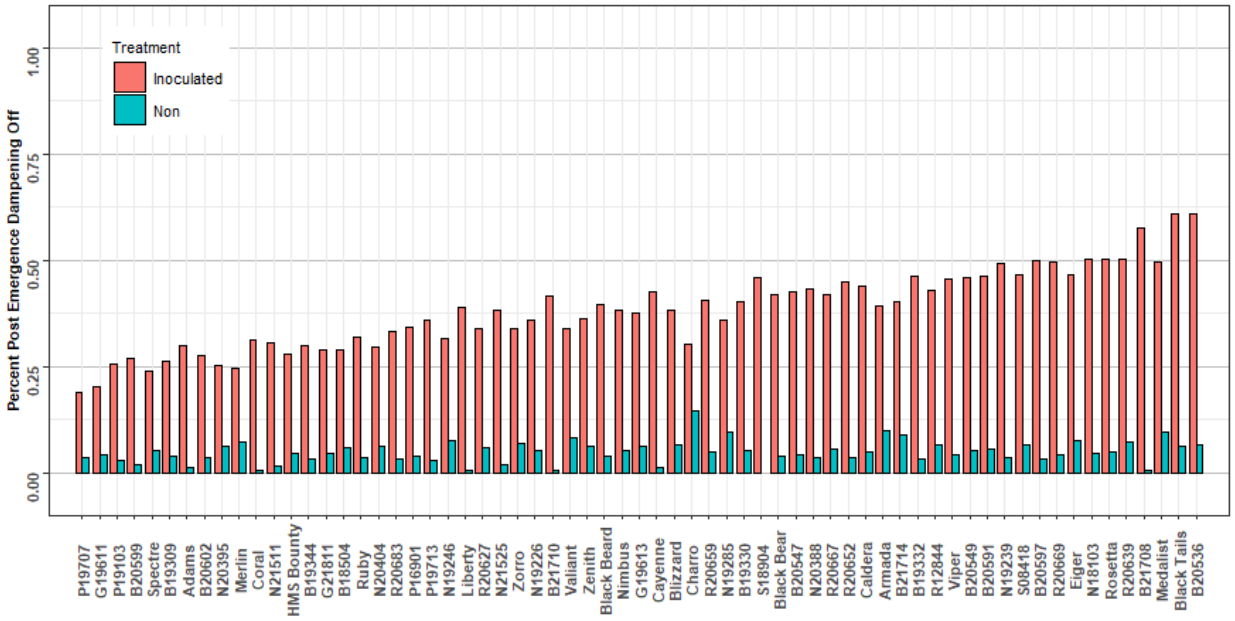

Figure 1. LSMeans for percentage of post-emergence damping-off between inoculated vs non-inoculated for 64 lines evaluated in East Lansing, MI during 2021 and 2022. Inoculated plots were inoculated with *Rhizoctonia solani*.

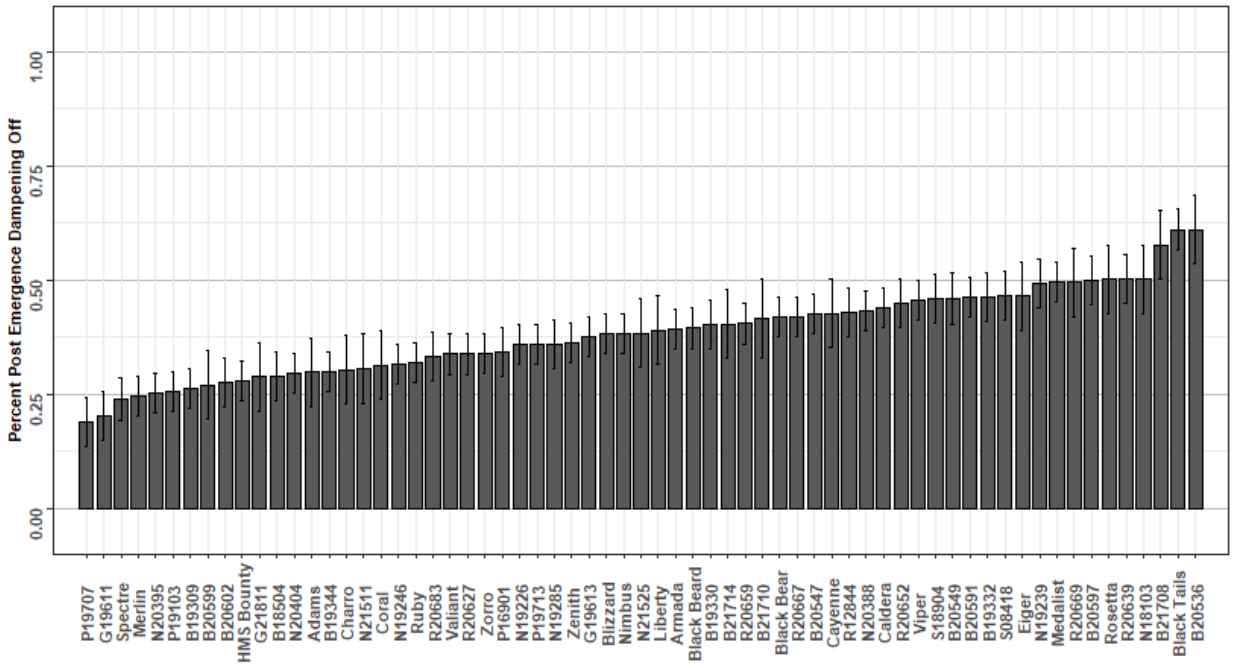

Figure 2. Root rot screening for 64 genotypes evaluated in East Lansing, MI inoculated with *Rhizoctonia solani*. Percentage post-emergence damping-off was estimated by calculating the difference between first and last stand count divided by the first stand count. Standard error bars label each barplot.

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan State University AgBioResearch

Overlapping residuals for waterhemp control in dry edible beans

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

Location: Shiawassee County	**Tillage:** Conventional
Replicated: 4 times	**Row width:** 30-inch
Planting Date: May 20, 2021 July 6, 2022	**PRE application date:** May 20, 2021 June 14, 2022
Variety: 'Zenith' ('21) & 'Adams' ('22) black beans	**POST application date:** June 16, 2021 July 26, 2022

Table 1. Waterhemp control 21 and 56 d after POST treatment (DAT) from overlapping residuals alone and with Reflex (2021 & 2022).

		Waterhemp control			
		2021		2022	
Herbicide treatments		**21 DAT**	**56 DAT**	**21 DAT**	**56 DAT**
PREs	**POST[a]**	— % —	— % —	— % —	— % —
None	Reflex (1 pt)	81	61	100	100
None	Outlook (21 fl oz) + Reflex (1 pt)	91	81	100	100
None	Dual II Magnum (2 pt) + Reflex (1 pt)	97	86	100	100
None	Warrant (3 pt) + Reflex (1 pt)	95	81	100	100
Outlook (11 fl oz)	Outlook (10 fl oz) + Varisto (21 fl oz)	99	95	100	98
Dual Magnum (1 pt)	Dual Magnum (1 pt) + Varisto (21 fl oz)	96	88	100	100
Warrant (1.5 pt)	Warrant (1.5 pt) + Varisto (21 fl oz)	99	89	100	99
None	Reflex (1 pt) + Varisto (21 fl oz)	81	68	99	99
Outlook (11 fl oz)	Outlook (10 fl oz) + Reflex (1 pt) + Varisto (21 fl oz)	100	96	100	100
Dual Magnum (1 pt)	Dual Magnum (1 pt) + Reflex (1 pt) + Varisto (21 fl oz)	100	100	100	100
Warrant (1.5 pt)	Warrant (1.5 pt) + Reflex (1 pt) + Varisto (21 fl oz)	100	98	100	100
	Untreated	0	0	0	0
$LSD_{0.05}$[b]		*8.1*	*11.5*	*2*	*3*

[a] All treatments were applied with crop oil concentrate (COC) (1% v/v) + AMS (2.5 lb).
[b] Means within a column greater than least significant difference (LSD) value are different from each other.

Summary: Herbicide-resistant waterhemp is becoming more prevalent throughout Michigan. Even though glyphosate is not a major component for weed control in dry bean, ALS-resistant waterhemp is wide spread. Additionally, a few populations have also been found to be resistant to the Group 14 herbicides (Reflex) limiting potential options for waterhemp control in dry bean. Overlapping residual herbicide programs may be one potential way to effectively control glyphosate-resistant waterhemp. Currently, **Outlook** is the **only residual** (Group 15) herbicide labeled for **early POST** applications in dry bean. However, we also wanted to compare Outlook with other Group 15 herbicides that could potentially be labeled as early POST applications in the future. Field studies were conducted in 2021 and 2022 in Shiawassee County on fields that had known populations of glyphosate- and ALS-resistant

waterhemp. We compared full-rate and split-applications (PRE followed by EPOS) of the Group 15 herbicides Outlook, Dual Magnum, and Warrant with and without Reflex. Reflex was included to control any emerged waterhemp. In 2021, Reflex alone provided approximately 80% waterhemp control 21 DAT and was significantly lower by the end of the growing season. When a residual was added, control was higher due to the residual activity on later emerging waterhemp. The split applications of the residual herbicides generally resulted in greater control later in the season (late- August). In our 2022 trial, we applied the PREs in mid-June, but due to poor dry bean emergence we terminated the dry beans and replanted on July 6. Due to the later planting all treatments including Reflex alone controlled waterhemp greater than 95% through harvest. Dry beans were harvested in 2022 and none of the residual or overlapping residual treatments resulted in any reductions in yield. The highest yield was 26.2 cwt/A and yield from the untreated control was 14.2 cwt/A resulting in a 45% reduction in yield due to waterhemp competition. Overall, these results show that if a grower has or is concerned about waterhemp in their dry beans a program they should consider applying is a split- application of Outlook, PRE followed by EPOS, especially if Reflex is in the POST application. This treatment provided excellent waterhemp control. This treatment will only work if the waterhemp is not Group 14 (PPO-resistant) and if the residual treatments receive some precipitation to incorporate the herbicide into the weed seed germination zone. We will continue to examine different options to control herbicide-resistant waterhemp.

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

			ANNUAL BROADLEAVES									ANNUAL GRASSES								PERENNIALS				
	SITE OF ACTION	CROP TOLERANCE**	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
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	15	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
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	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
OUTLOOK[d]	15	2	N	N	P	**G**	**G**	P	P	N	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	P	N	N	N	N	F
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[e]	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[e] + 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[e]	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[e] + 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[ef] + 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[f]	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] *Outlook* will not control emerged weeds but will provide residual control of the above listed species including waterhemp.

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

[f] **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.
	dimethenamid-P *(Outlook)*	0.66	14 oz 6L	• **Apply preplant incorporated only.** • Refer to Table 5A for weed control and crop tolerance ratings. • *Outlook* may be applied early postemergence. Refer to the postemergence section for more information. • Reduce the *Outlook* rate to 12 oz/A on coarse-textured soil with low organic matter. • Navy and black beans are more sensitive to *Outlook* applications than *Dual Magnum.* • *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 weed 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.
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.

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Dry Edible Beans — Preplant Incorporated Only *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
(continued)				
Annual grasses **Annual broadleaves**	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 .
	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 .

(Continued on next page)

Dry Edible Beans — Soil Applied *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
(continued)				
Annual grasses	glyphosate + s-m etolachlor *(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.
	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.

(Continued on next page)

Dry Edible Beans — Soil Applied *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
(continued)				
Annual broadleaves	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.

(Continued on next page)

Dry Edible Beans — Postemergence *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
(continued)				
Grasses	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 .
	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 .
Residual annual grass control	dimethenamid-P *(Outlook)*	0 .47	10 oz 6L	• Refer to Table 5A for weed control and crop tolerance ratings . • *Outlook* may be applied from the first to the third trifoliate stage . • *Outlook* will not control emerged weeds but will provide re- sidual control of annual grasses and some broadleaf weeds, including waterhemp . • Postemergence applications may result in temporary spot- ting or browning of dry bean leaves and stunting . • Tank mixtures with other postemergence herbicides may result in increased dry bean injury . • DO NOT exceed a total of 21 oz/A of *Outlook* per season . • 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 .

Dry Edible Beans — Postemergence *(continued)*

Weed Controlled	Herbicide	Rate lb/A a.i.	Formulation/A	Remarks and Limitations
Annual broadleaves	bentazon *(Basagran)* 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.
	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.

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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	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 .
	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 .

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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	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)* OR *(Gramoxone SL 3.0)* + surfactant	0.3-0.5	1 .2–2 pt 2SL OR 0.8-1.33 pt 3SL + 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: **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*; 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* or 1 .33 pt/A of *Gramoxone SL 3.0.* • Do not harvest within 7 days of application .
	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 .

(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	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 .

MSU Field Crops Insect Guide: Management of Insects and Spider Mites in Dry Beans
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How to Use this Guide

This publication is set up as a series of stand-alone tables with information on insect biology, damage, management recommendations, and insecticides registered in Michigan on **dry beans**. Pesticide names and rates are current as of the date at the top of the page.

- ✓ **Table 1** shows the timing of common insect pests in the crop, from early to late season.

- ✓ **Table 2** is a checklist of damage symptoms from these insects to aid in field scouting.

- ✓ **Table 3** has information on the life cycle of each insect, plus a detailed description of its damage and the conditions that may lead to or favor infestations. A rating of pest status (and thus damage potential) is given based on experience in the state. Most insect pests are uncommon or do not increase to damaging levels in a typical year.

- ✓ **Table 4** has information on management of each pest. Most insects are kept in check by natural enemies (biological control) or by adverse environmental conditions. Some pest problems can be reduced by simply changing or avoiding certain agronomic practices. Table 4 also gives scouting and threshold recommendations. Note that these recommendations vary in quality. Key pests tend to have research-based scouting methods and thresholds. But many insects are not at damaging levels often enough to generate good information; sampling recommendations and thresholds for these species are based on observations, experience, or a best guess. This is noted in the table.

- ✓ Insecticides registered in Michigan on the crop are listed in **Table 5** (at planting) and **Table 6** (foliar sprays)**.** Active ingredients (AI) are listed alphabetically in column 1. All products with the same active ingredient are grouped together under each AI for easy comparison or substitution of one product for another. Label rates and pests are listed in columns 2 and 3. A letter under a pest indicates that a particular insect is on the label (i.e., the label claims control of that insect). The letter corresponds to an application rate in column 2. Some insecticides are applied at a single rate for all insects ('a'), while others vary ('a', 'b', 'c'). The final columns in the table list the preharvest interval (PHI) in days and notes on application - for example bee toxicity warnings, minimum recommended spray volumes, or other restrictions.

Dry beans Table 1. Timing of damage from common insects and related pests in Michigan
Pests are listed from early to late-season. Key species are highlighted in bold text.

Common name	Overwintering stage, location	May	June	July	August	September
seedcorn maggot	pupae, in soil	larvae (maggots) feed on seeds and scar cotyledons				
slugs & snails	both eggs and adults, in field	juveniles and adults feed on seedlings				
white grubs	larvae (grubs), underground	larvae (grubs) feed on roots				
aphids (usually black bean & cotton aphids)				nymphs and adults pierce leaves, feed on plant sap		
grasshoppers (multiple species)	egg clusters, underground			nymphs and adults feed on leaves		
green cloverworm	Southern USA, migrate north			larvae (caterpillars) feed on leaves and pods		
Mexican bean beetle	adults, in protected areas			larvae and adults skeletonize leaves		
potato leafhopper	Southern USA, migrate north			nymphs and adults suck plant sap		
spider mite	adult females, at base of hosts			nymphs and adults pierce plant cells, suck plant sap		
Lygus / tarnished plant bug	adults, in protected areas			nymphs and adults suck plant sap		
thrips	depends on species			nymphs and adults 'punch' individual cells, suck plant sap		
western bean cutworm	prepupae, underground			larvae (caterpillars) feed on blossoms and developing pods, then chew into beans		
European corn borer	larvae, in corn residue				second generation larvae bore stems & chew into pods, beans	
stink bug	adults, in & around fields				nymphs and adults suck plant sap, pierce developing pods	

Dry Beans Table 2: Damage checklist to aid in scouting for insects and related pests.

Plant part or timing Type of damage or injury	aphids	European corn borer	grasshoppers	green cloverworm	Mexican bean beetle	plant bug	potato leafhopper	seedcorn maggot	slugs & snails	spider mite	stink bugs	thrips	western bean cutworm	white grubs
Stand (emergence)														
seeds fed-on								x	x					x
gaps in row								x	x					x
wilted or cut plants														x
Leaves														
slimy or shiny trails									x					
scraping of leaf surface					x				x					
skeletonizing between veins					x									
irregular leaf feeding			x	x										
severe defoliation			x	x	x									
generalized leaf yellowing	x					x				x				
yellow leaf margins (hopperburn)							x							
tiny yellow spots (stippling)										x		x		
leaves cupped, crinkled	x					x	x			x		x		
sticky leaves or sooty mold	x													
fine webbing										x				
leaf drop, death							x			x		x		
Stems														
boring into stem		x												
powdery frass		x												
Roots														
root hairs missing														x
pruning of whole roots														x
Pods and beans														
large holes chewed into pod		x	x										x	
small holes chewed into pod		x		x									x	
beans fed-on in pod		x	x										x	
shriveled, aborted beans						x					x			
Other														
virus transmission	x													

Dry Bean Table 3: Life cycle, damage, and pest status of insects in dry beans

Pest status is rated as follows. Rating applies to Michigan.

- Rare: Insect is *unusual, not found in most fields*
- Uncommon: Insect is present in many fields, but *typically not in damaging numbers*
- Occasional: Insect is present in most fields, *sometimes increasing to damaging levels*.
- Important: Insect is present in most fields, *often increasing to damaging levels*; often a target of integrated management or insecticide use by growers.

- Sporadic: Economic outbreaks may occur in certain fields or seasons after *extreme weather* or *mass movement* from south to north early in the season
- Localized: Economic outbreaks may occur in specific locations under *specific agronomic conditions*, for example, in no-till or in late plantings.

Pest (abbreviation)	Life cycle and Number of generations	Description of Damage	Conditions which favor infestation or damage	Pest Status in Michigan
aphids	Summer population is all female. Females give birth to live young and do not mate to reproduce (parthenogenesis). Multiple overlapping generations	• All stages suck plant sap from leaves • Heavy infestation may lead to stunting, curling of leaves, weakening of plants • Aphids also transmit plant viruses	• Drought stress may be made worse by aphids removing plant sap	Uncommon Usually present, but numbers not enough to cause damage
bean leaf beetle	Adults overwinter in leaf litter and wooded field margins. Become active in spring; move into alfalfa, then migrate into beans after first alfalfa cutting. Larvae feed underground on roots. 1-2 generations per year	• Adults defoliate younger plants, leaving small round holes between major leaf veins • Adults feed on and scar developing pods, reducing yield and seed quality	• Adults may move into dry beans if nearby soybean fields were infested in the previous or current season	Uncommon Usually present, but numbers rarely high enough to cause damage
European corn borer (ECB)	Mature larvae overwinter in corn residue and pupate in late spring. Moths emerge in late May-early June and lay eggs in corn and other crops. Two generations in south & central Michigan, the first in June & the second in late July/ early August. One generation in the UP and northern Michigan.	• Older larvae bore into stem, disrupt water flow, weaken stem • Larvae also bore into pods, consume seeds, and contaminate harvested beans	• Nearby non-Bt corn production probably increases local ECB risk	Uncommon Populations suppressed by widespread use of Bt GMO corn
grasshoppers *multiple species*	Eggs overwinter in soil. Nymphs emerge in June. Amount of feeding increases with size. Females lay groups of eggs in the undisturbed soil in late summer. 1 generation per year	• All stages chew on leaves; feeding has a ragged appearance	• Fallow areas and pasture are preferred egg-laying sites • A hot dry summer & fall can lead to a high population the next year	Uncommon Outbreaks rare, usually after a dry season
green cloverworm	Adults lay eggs singly on underside of leaves; larvae feed on foliage	• Small caterpillars scrape leaf tissue while older larvae defoliate plants		Uncommon Usually present, but numbers rarely high enough to cause damage

Pest (abbreviation)	Life cycle and Number of generations	Description of Damage	Conditions which favor infestation or damage	Pest Status in Michigan
Mexican bean beetle	Adults overwinter in crop debris, woodlots, etc. Adults move into dry beans in early summer and lay eggs. Larvae mature in 3-4 weeks, pupating on leaf surface. Adults emerge in late July into August, lay eggs for a second generation. Second generation larvae feed, pupate in late August, and new adults overwinter.	• Larvae and adults strip the leaf surface between the veins on the underside of leaves, resulting in windowpane damage or a skeletonized (lacy) appearance. Time frame: mid-July into August. • Pod feeding is rare	• A mild winter increases survival • Planting adjacent to fields with high populations the previous year • Early-planting (adults attracted to these fields)	Uncommon and Localized
potato leafhopper (PLH)	Adults are carried into Michigan from the south on weather fronts in May/early June. Females lay eggs inside stems. Nymphs hatch in 7-10 days, begin feeding immediately, and reach adult stage in 2-3 weeks. Multiple overlapping generations	• Adults and nymphs lacerate and suck on leaves and stems, damaging cells and blocking vascular tissue; the classic symptom of feeding is tip yellowing or 'hopper burn' • Other symptoms include stunting and curling of leaves and poor pod fill	• PLH damage is worse under dry conditions, and leafhopper survival is probably better too	Sporadic *later in season*: Important, if populations become well-established
seedcorn maggot (SCM)	SCM overwinters as pupae in the soil. Adult flies emerge in early spring and are attracted to lay eggs in disturbed soil with decaying organic matter. Multiple generations	• Tiny larvae (maggots) feed on germinating seed; may cause variable emergence, stand loss, and delayed development	• Cool wet conditions which delay germination • Tillage of fields with high organic matter from a decaying green cover crop, or weeds, or fresh manure	Sporadic and Localized Depends on presence of fresh organic matter and cool, wet conditions
slugs & snails	Slugs overwinter as both eggs & adults; females deposit eggs in soil; these hatch in about one month. Multiple overlapping generations	• Feeding on cotyledons & lower leaves; feeding usually occurs at night • Substantial defoliation can be tolerated in pre-bloom dry beans, but if the growing point is killed, stands can be significantly reduced	• Planting into heavy crop residue • Cool, wet soils which delay germination • Poorly closed furrows (slug highways)	Localized Depends on residue and cool conditions. Dry beans are usually planted after slug risk is past.
spider mite	Adult females overwinter in field borders and sheltered areas. In spring, they move to new growth, and lay eggs. Mites spread from field to field by crawling or blowing in the wind. Multiple overlapping generations	• Adults & nymphs pierce individual plant cells, resulting in tiny yellow spots called stippling • Webbing is a sign of a heavy infestation • Severe damage results in leaf yellowing, death, water loss	• Prolonged hot, dry weather favors outbreaks and enhances the impact of feeding • Infestations often start on dusty edges of fields	Sporadic Outbreaks occur in hot, dry seasons
stink bug *several species including green, onespotted, & the brown marmorated*	Adults overwinter in protected areas. Weeds and early crops like wheat are fed on and colonized first. Stink bug eggs, laid in small clusters, often sport a small 'crown'. Nymphs and adults live and feed in the crop together. Note - some stink bug species are beneficial predators of other insects like caterpillars	• Adults and nymphs feed by injecting salivary enzymes into plants and sucking up plant juices • Feeding on pods can result in aborted or shriveled beans	• May move into dry beans as adjacent wheat fields dry down	Uncommon Numbers rarely high enough to cause damage
tarnished plant bug (TPB)	Adults overwinter in residue and on field edges. Weeds and early crops like alfalfa are fed on and colonized first.	• Adults and nymphs suck plant sap. Tarnished plant bug injects a toxic saliva during feeding. • Feeding on pods can result in aborted or shriveled beans	• May move into dry beans from adjacent alfalfa fields that were recently cut	Uncommon Numbers rarely high enough to cause damage

Pest (abbreviation)	Life cycle and Number of generations	Description of Damage	Conditions which favor infestation or damage	Pest Status in Michigan
thrips	Adults and nymphs overwinter in residue. Populations initially build on grasses and in wheat. Note that thrips are an important food source for some of the beneficial insects, such as pirate bugs, that control other pests.	• Nymphs and adults feed with a single mandible, using it to puncture plant cells and slurp up the liquid inside • Punctured cells dry up, resulting in areas of dead cells; under heavy infestation, leaves dry up, curl, or die	• Dry conditions in early summer • May move into dry beans from adjacent wheat fields or grassy borders that are drying down	Uncommon Usually present, but numbers rarely high enough to cause damage
western bean cutworm (WBC)	Overwinter in pre-pupal stage. Adults emerge in mid-late July; females lay eggs in pre-tassel corn and switch to dry beans as corn matures. Larvae feed on pods at night. In early-September, they drop & burrow into soil to over-winter. Areas with sandy soil appear to have deeper and better overwintering. 1 generation per year	• Tiny larvae feed on leaves and then inside blossoms • Larger larvae drop to the ground & stay under residue or in cracks during the day. They climb into the canopy to feed on pods at night	• Areas with sandy soils, where over-wintering survival is higher • Adjacent corn which is no longer attractive for egg laying (ie. past the pretassel stage)	Occasional - Important Montcalm and surrounding counties + the UP are historic hot spots for WBC
white grubs *multiple species*	Mature grubs overwinter under-ground. Adults emerge May-July, depending on species. Eggs laid in soil in the summer. Grubs feed on roots, then move down in soil profile in late fall to overwinter. In spring, grubs feed for a period, then pupate. 1 generation per year except June beetle, which has a 2-3 year life cycle	• Larvae (grubs) prune root hairs and sometimes whole roots, causing wilting, water and nutrient deficiency, or plant death	• planting into fallow fields or pasture • fields near pasture, home lawns • Fields or parts of fields with sandy soil type	Uncommon

Dry Beans Table 4: Management notes, scouting recommendations, and thresholds.

Pest (abbreviation)	Notes on non-chemical and chemical management	Scouting recommendation	Spray threshold
aphids	• Biological: Predators (such as ladybugs, lacewings, parasitoids) keep populations in check. Under humid conditions, entomopathogenic fungi infect aphids. • Environmental: Heavy rainfall and irrigation can wash off aphids. Adequate moisture reduces feeding stress and increases humidity for infection by pathogens.	Check 100 plants (20 plants x 5 sets)	General guideline: One or more aphid colony (a group of about 30) per plant Rarely justified
bean leaf beetle	• Environment: Extended periods of cold winter temperatures may increase kill of overwintering beetles	Check 100 plants (20 plants x 5 sets)	General guideline: More than 10% of the pods damaged Rarely justified
European corn borer (ECB)	• Biological: Numerous natural enemies kill ECB eggs and larvae. Predators, egg and larval parasitoids, and pathogens are common. • Agronomic: The widespread planting of Bt corn has greatly reduced the European corn borer population in the landscape.	No specific recommendation Note: Trapping can detect large corn borer flights. Michigan moths respond to Z (Iowa) strain pheromone	None
grasshoppers	• Biological: blister beetle larvae and other insects prey on eggs, and insects, birds, and mammals eat nymphs & adults. Fungal pathogens kill eggs and nymphs under wet spring conditions. • Agronomic: Tillage reduces survival of eggs and newly hatched nymphs • Insecticide: May be able to limit sprayed area if hoppers invade from a neighboring field or grassy border	No specific recommendation Have never seen populations high enough to treat in Michigan	General guideline: During flowering & pod fill, 15% overall defoliation by leaf-feeding insects, including hoppers
green cloverworm	• Biological: many natural enemies keep it in check	No specific recommendation Cloverworm can be detected by sweeping or beating plants over a cloth laid between rows	General guideline: During flowering & pod fill, 15% overall defoliation by leaf-feeding insects, including cloverworm
Mexican bean beetle (MBB)	• Biological: natural enemies feed on eggs and larvae • Agronomic: avoid early planting, as overwintered adults colonize these fields first • Environmental: Hot, dry weather and heavy rainfall are both cited as reducing populations	Early-mid July: Scout for # egg masses per meter. Take multiple samples across the field During flowering & pod fill: estimate defoliation	General guideline – 0.5 egg masses per meter/yard or 15% overall defoliation by leaf-feeding insects, including MBB
potato leafhopper (PLH)	• Biological - a naturally occurring fungal pathogen reduces PLH numbers under favorable conditions, usually later in the year • Insecticides: resistance is not an issue with PLH	Check 100 trifoliates from different plants (20 leaves x 5 sets) Count both adults and nymphs	Unifoliate stage: > 0.5 leafhopper per plant Otherwise: > 1 leafhopper per trifoliate leaf
seedcorn maggot (SCM)	• Agronomic: Potential for injury increases in wet, cool springs when seed germinates slower, or when seed is planted into tilled fields where fresh green material (cover crops or weeds) have been worked in. Risk drops after organic matter decomposes. Risk is very low in no-till fields. • Insecticide: Management is preventative, using a seed treatment in tilled fields where weeds and cover crop were recently killed or manure applied.	No specific recommendation	No rescue treatment is available. Consider replanting fields or areas with significant stand loss

Pest (abbreviation)	Notes on non-chemical and chemical management	Scouting recommendation	Spray threshold
slugs & snails	• Biological: Some ground beetle species consume slugs • Agronomic: Tillage and crop rotation reduce corn residue (slug habitat). Avoid planting in wet conditions, as open furrows act as slug highways. • Insecticide: Slugs are not insects, thus soil insecticides and seed treatments have no impact on them. Some studies suggest that seed treatments actually exacerbate slug populations by killing their ground beetle predators.	No specific recommendation Walk fields at night or early morning, turning over residue and looking for slime trials	None established A guess: Consider applying a molluscicide (slug bait) if stand is reduced by 5%
spider mite	• Biological: Under humid conditions, a natural fungal pathogen can infect and wipe out mite populations in a matter of days. Some natural enemies eat mites. • Agronomic: Irrigation mitigates the impact of spider mite feeding and increases humidity for fungal biocontrol, but during a drought, even irrigation isn't enough. • Environmental: Rainfall has a similar effect as irrigation • Insecticide: Insecticide resistance is common in mites. Some insecticides (including most pyrethroids) flare mite populations by killing off natural enemies. Likewise, fungicide applications may disrupt fungal pathogens of mites. Insurance applications of both are discouraged; be cautious about pesticide applications in dry years.	Infestations often start on field edges Look for mites on undersides of leaves using hand lens, or tap leaves over a black piece of paper Webbing is present when populations are high	A guess: Treat when mites appear on >25% of the plants and yellowing is first seen Mites are difficult to control; spraying is often a losing proposition
stink bugs	• Biological: Several parasitoids attack egg masses or bugs	No specific recommendation	None established
tarnished plant bug	• Agronomic: Good weed control reduces alternate hosts for plant bugs	No specific recommendation	General guideline: One bug or more per plant at first flower to green pod stage
thrips	• Biological: Generally kept in check by predators. • Environmental: Rainfall or irrigation reduces populations. • Insecticides: Onion thrips are killed better by pyrethroids than OPs/ carbamates. A caution about spraying: Thrips can be viewed as semi-beneficial, because they are predators of spider mite eggs. Spraying for thrips may contribute to a spider mite outbreak in the future, especially under dry conditions.	Infestations often start on field edges Look for thrips on undersides of leaves using hand lens. Or tap leaves over a white piece of paper or a paper plate	Threshold used in the High Plains (not tested in Michigan): >15 thrips per plant and leaf cupping is present
western bean cutworm	• Biological: many predators consume eggs and larvae; tiny Trichogramma wasps have been seen in the field in Michigan parasitizing egg masses	Sampling beans directly for WBC eggs of larvae is difficult Use bucket-type pheromone traps to detect flight, starting at the end of June. At a cumulative catch of 100-120 moths, scout fields for pod feeding	Action threshold developed In the Great Lakes Region: Treat when >10% of pods are fed-on by WBC larvae
white grubs	• Biological: Some species are attacked by pathogens • Agronomic: If practical, fall plowing of long-standing fallow fields & pasture prior to planting is recommended. Tillage also exposes grubs to mammals and birds. Note: It is important to identify grubs to distinguish annual species from multi-year species of June beetles.	No specific recommendation Grubs tend to be patchy, and in sandy parts of fields Grubs are sometimes detected when plowing in the fall or spring	None established

Dry Beans Table 5: Insecticides registered on dry beans in Michigan for use at planting, with preharvest intervals and precautions

- Insecticides are grouped by active ingredient(s), which are listed alphabetically, allowing for easy comparison of products with the same chemistry.
- Application rates are listed for pests which appear on the manufacturer label; If a column is blank, the pest is not on the label. The letters in the pest columns refer to the label use rate from column two.
- Note that insecticide rates per 1000 feet of row are based on a **30-inch row spacing**. See label for specific per-acre rate and gauge-setting charts for narrower row spacing.

Active ingredient Trade Names	**Labelled rate(s)** per 1000 feet of row or per acre	**seedcorn maggot**	**slugs & snails**	**white grubs**	**Precautions and Remarks**
bifenthrin					
Xpedient Plus V	(a) 0.15 – 0.30 oz per 1000 ft (= 2.56 - 5.12 oz per acre)	a		a	• Apply T-band or in-furrow; see label for PRE and PPI instructions
Bifender FC	(a) 0.17 - 0.34 oz per 1000 ft (= 3.0 - 5.9 oz per acre)				Note: Many of these products can be broadcast soil surface to control black cutworm and armyworm.
Capture 3RIVE3D	(a) 0.19 – 0.46 oz per 1000 ft (= 3.2 - 8 oz per acre)				
Bifenture LFC Capture LFR Sniper LFR	(a) 0.2 - 0.39 oz per 1000 ft (= 3.4 - 6.8 oz per acre)				
bifenthrin + biofungicide *(Bacillus amyloliquefaciens)* Ethos XB	(a) 0.2 - 0.49 oz per 1000 ft (= 3.4 - 8.5 oz per acre)	a		a	• contains a biological fungicide strain for suppression of early season root diseases. • Apply T-band or in-furrow; see label for PRE and PPI instructions
cypermethrin (zeta)					
Mustang	(a) 0.247 oz per 1000 ft (= 4.3 oz per acre)			a	• Apply T band or in-furrow in a minimum of 2-7 gal per acre
Mustang Maxx	(a) 0.23 oz per 1000 ft (= 4 oz per acre)				
iron phosphate					
Sluggo	(a) 0.5 – 1.0 lb per 1000 ft (= 20 - 44 lbs per acre)		a		• Broadcast using a spreader • Apply bait in evening when slugs feed; product works best when the soil is moist

Dry Beans Table 6: Foliar insecticides registered on dry beans in Michigan, with preharvest intervals and precautions.

- Insecticides are grouped by active ingredient(s), which are listed alphabetically, allowing for easy comparison of products with the same chemistry.
- Application rates are listed for pests which appear on the manufacturer label; If a column is blank, the pest is not on the label. The letters in the pest columns refer to the label use rate from column two.
- Acronyms: BLB-bean leaf beetle; ECB-European corn borer; GCW-green cloverworm; MBB-Mexican bean beetle; PLH-potato leafhopper; TPB-tarnished plant bug; WBC-western bean cutworm

Active ingredient Trade Names	**Labelled rate per acre** (unless stated)	**aphids**	**BLB**	**ECB**	**grasshopper**	**GCW**	**MBB**	**PLH**	**spider mite**	**stink bug**	**TPB**	**thrips**	**WBC**	**Pre harvest interval (PHI) in days**	**Precautions and Remark**
abamectin															
Abba Ultra	(a) 4 - 8 oz								a					7	• Ground application recommended (instead of by air), at minimum 10 gal per acre • To avoid the chance of illegal residue, product must be applied with a "non-ionic activator type wetting, spreading or penetrating spray adjuvant" that is approved on dry beans. See label for details
Agri-Mek SC	(a) 1.75 - 3.5 oz														
acephate															
Acephate 90WDG Acephate 90WSP	(a) 4 - 8 oz (b) 8 - 17.6 oz (c) 12.8 - 17.6 oz	b	b	c	a	b	b	b			b	b		14	• Minimum 20 gal per acre (ground) or 2 gal per acre (air) • Do not feed treated vines to livestock • WSP formulation is in water soluble packets
Acephate 90 Prill	(a) 4.4 - 8.9 oz (b) 8.9 - 17.6 oz (c) 13.3 - 17.6 oz														
Acephate 97UP Acephate 97 WDG Orthene 97	(a) 4 - 8 oz (b) 8 - 16 oz (c) 12 - 16 oz														
Bacillus thuringiensis (Bt)															
Agree	(a) 0.5 - 2.0 lbs					a								0	• Larvae must eat treated foliage to be killed, so good coverage is needed • Bt sprays are most effective on small caterpillars • Biobit, Dipel DF, and Xentari can be used on organic beans
Biobit HP	(a) 0.5 - 1 lb														
Dipel ES	(a) 1 - 2 pints														
Javelin	(a) 0.25 - 1.5 lbs														
Xentari DF	(a) 0.5 - 1.5 lb														
bifenazate															
Acramite 4SC	(a) 16-24 oz								a					7	• Apply in minimum of 20 gal per acre (ground) or 7 gal per acre (air) • Max 2 applications per year; 14 days between sprays

Active ingredient Trade Names	**Labelled rate per acre** (unless stated)	**aphids**	**BLB**	**ECB**	**grasshopper**	**GCW**	**MBB**	**PLH**	**spider mite**	**stink bug**	**TPB**	**thrips**	**WBC**	**Pre harvest interval (PHI) in days**	**Precautions and Remark**
bifenthrin Bifen 2AgGold Bifenthrin 2EC Bifenture EC Brigade 2EC Fanfare EC, 2EC, and ES Sniper & Sniper Helios Tundra EC	(a) 1.6 - 6.4 oz (b) 2.1 - 6.4 oz (c) 5.12 - 6.4 oz	b	b	b	b	a b	b	a	c	b	b	b	b	14	• Maximum 0.3 lb/ acre of active ingredient per season • Do not make applications less than 7 days apart • Extremely toxic to bees; See labels for details
bifenthrin + a biofungicide *(Bac. amyloliquefaciens)* Ethos XB	(a) 2.8 - 8.5 oz	a	a	a	a	a	a	a	a	a	a	a	a	14	• Contains a biological fungicide strain - otherwise similar to bifenthrin
bifenthrin + cypermethrin (zeta) Hero Hero EW Steed	(a) 4.0 - 10.3 oz (b) 10.3 oz (a) 4.5 - 11.2 (b) 11.2 oz (c) 3.5 - 4.7 oz	a c	a c	a c	a c	a c	a c	a c	b	a c	b	b c	a c	21	• Do not make applications less than 7 days apart • Max 27.39 oz (Hero), 29.86 (Hero EW) of product per season
bifenthrin + imidacloprid (1:1 ratio) Brigadier Swagger	(a) 3.8 - 5.6 oz (b) 5.6 oz (a) 7.6 - 11.2 oz (b) 11.2 oz	a	b	b	a	b	b	a			a	a		14	• Do not make applications less than 7 days apart • Extremely toxic to bees; See label for details
bifenthrin + imidacloprid (2:1 ratio) Skyraider	(a) 2.1 - 5.6 oz (b) 5.12 - 5.6 oz	a	a	a	a	a	a	a	b	a	a	a	a	14	• Do not make applications less than 7 days apart • Extremely toxic to bees; See label for details
carbaryl Carbaryl 4L Sevin 4F Sevin XLR Plus	(a) 0.5 - 1.0 qt (b) 1.0 qt (c) 1.0 - 1.5 qt		a	c		a	a	b		c	c	b	b	21 beans 14 forage	• Applications interval minimum of 7 days • Application to wet foliage or in periods of high humidity may cause plant injury • "May kill honey bees and other bees in substantial numbers"; do not apply when crop or weeds are in bloom. See labels for additional details
chlorantraniliprole Coragen Prevathon	(a) 2 - 5 oz (b) 3.5 - 7.5 oz (a) 8 - 20 oz (b) 14 - 20 oz			b	a								b	1	• Thorough coverage is important; insects must eat treated foliage for optimum control • See label for specific directions for grasshopper control

Active ingredient Trade Names	**Labelled rate per acre** (unless stated)	**aphids**	**BLB**	**ECB**	**grasshopper**	**GCW**	**MBB**	**PLH**	**spider mite**	**stink bug**	**TPB**	**thrips**	**WBC**	**Pre harvest interval (PHI) in days**	**Precautions and Remark**
chlorantraniliprole + cyhalothrin (lambda) Besiege	(a) 5 - 8 oz (b) 6 - 10 oz (c) 10 oz	b	b	b	b	a	a	b	c	b	b	b	b	21	• Do not graze or harvest vines for forage • For mites, suppression only
cyantraniliprole Exirel	(a) 10.0- 20.5 oz			a										7	• Label lists suppression of potato leafhopper and thrips • See label statement about 'adverse crop response'
cyantraniliprole + abamectin Minecto Pro	(a) 7.5 - 10 oz			a						a				7	• Apply in minimum of 10 gal per acre ground or 5 gal per acre air; ground application recommended for coverage • Label lists suppression of potato leafhopper and thrips • See label statement about 'adverse crop response'
cyfluthrin Baythroid XL Tombstone Tombstone Helios	(a) 0.8 - 1.6 oz (b) 1.6 - 2.4 oz (c) 2.4 - 3.2 oz		c	c	c	c	c	a		b	b		*	7	• Do not feed treated vines or hay to livestock * Western bean cutworm is not on the current labels, but cyfluthrin is labeled for WBC in corn
cyfluthrin + imidacloprid Leverage 360	(a) 2.4 - 2.8 oz	a	a	a	a	a	a	a			a			7	• Label lists suppression of stink bugs at high rate • Do not feed treated vines or hay to livestock
cyhalothrin (gamma) Declare Proaxis	(a) 0.77 - 1.28 oz (b) 1.28 - 1.54 oz (a) 1.92 - 3.30 oz (b) 2.56 - 3.84 oz	b	b	b	b	a	a	b		b	b	b	b	21	• Do not graze or harvest vines for forage
cyhalothrin (lambda) Grizzly Too Lamcap II Province II Warrior w/Zeon Kendo Lambda-Cy Lambda-Cy Ag Lambda Cyhalothrin 1EC LambdaStar Lambda-T Paradigm VC Silencer Willowood Lambda-Cy1EC	(a) 0.96 - 1.60 (b) 1.28 - 1.92 (a) 1.92 - 3.2 (b) 2.56 - 3.84	b	b	b	b	a	a	b		b	b	b	b	21	• Max 7.68 oz / acre per season • Do not graze or harvest vines as forage or hay
cypermethrin (alpha) Fastac EC or CS	(a) 2.7 -3.8 (b) 3.2 - 3.9 oz	b	a	a	b	a	a	a		b	a	b	*	21	• CS formulation is microencapsulated * Western bean cutworm is not on the current labels, but cypermethrin is labeled for WBC in corn

Active ingredient Trade Names	**Labelled rate per acre** (unless stated)	**aphids**	**BLB**	**ECB**	**grasshopper**	**GCW**	**MBB**	**PLH**	**spider mite**	**stink bug**	**TPB**	**thrips**	**WBC**	**Pre harvest interval (PHI) in days**	**Precautions and Remark**
cypermethrin (zeta) Mustang Mustang Maxx	(a) 3.0 - 4.3 oz (b) 3.4 - 4.3 oz (a) 2.72- 4.0 oz (b) 3.2 - 4.0 oz	b	a	a	b	a	a	a		b	a	b	*	21	• Extremely toxic to bees. Do not apply to blooming crops if bees are visiting the field * Western bean cutworm is not on the current labels, but cypermethrin is labeled for WBC in corn
dimethoate Dimate 4E Dimethoate 400 and 4EC	(a) 0.5 - 1.0 pt	a	a		a		a	a	a		a			0	• Max 2 pints/ acre per year; 14-day retreatment interval • Do not feed treated vines • Highly toxic to bees
esfenvalerate Asana XL S-FenvaloStar Zyrate	(a) 2.9 - 5.8 oz (b) 5.8 - 9.6 oz				b	b	a	b					b	21	• Do not feed or graze livestock on treated vines • See label language about grasshopper control • Highly toxic to bees; See label for details
flupyradifurone Sivanto HL Sivanto 200 SL Sivanto Prime	(a) 3.5 - 7.0 oz (a) 7 - 10.5 oz (a) 7 - 14 oz	a						a						7	• Foliar applications have systemic properties; product moves from deposition point to leaf tips and controls insects on underside of leaves
imidacloprid Admire Pro Advise Four Alias 4F Montana 4F Nuprid 4F Max Wrangler Nuprid 2SC Prey 1.6F and Sherpa	(a) 1.2 oz (a) 1.4 oz (a) 2.8 oz (a) 3.5 oz	a						a						7	• Highly toxic to bees; See label for details
indoxacarb Steward	(a) 6.7 - 11.3 oz			a										7	• For ground application use minimum 20 gal per acre
methomyl Annihilate LV Corrida 29SL Lannate LV Nudrin LV	(a) 0.75 - 3 oz (b) 1.5 - 3 oz	b		b			a	a		*	b	b		14	• Kills both eggs and larvae of corn borer. See label for specific on timing • Highly toxic to bees. See label for details * The labels for Lannate list brown marmorated stink bug as a target

Active ingredient Trade Names	**Labelled rate per acre** (unless stated)	**aphids**	**BLB**	**ECB**	**grasshopper**	**GCW**	**MBB**	**PLH**	**spider mite**	**stink bug**	**TPB**	**thrips**	**WBC**	**Pre harvest interval (PHI) in days**	**Precautions and Remark**
methomyl continued Annihilate SP Corrida 90WSP Lannate SP Nudrin SP	(a) 0.25- 1 oz (b) 0.5 - 1 oz														
methoxyfenozide Intrepid 2F	(a) 8 - 16 oz			a										7	• Apply in minimum of 20 gal per acre (ground) in a full canopy or 10 gal per acre (air) • See label for information on application timing • Endangered species warning on label for applications made in these Michigan counties: Allegan, Monroe, Montcalm, Muskegon, Newaygo, Oceana
naled Dibrom 8E	(a) 1 pint (b) 1.5 pint	a				a		a	a	b	a			1	
pyrethrins Evergreen EC 60-6 PyGanic EC 1.4 II PyGanic Specialty	(a) 2.0 - 12.6 oz (a) 16 - 64 oz (a) 4.5 - 15.6 oz	a	a	a	a	a	a	a		a	a	a	a	0 when sprays dry	• Plant-derived insecticides that knock down insects quickly but have very short residual control. Coverage is critical • Max 10 applications per season, min 3-day spray interval • PyGanic is OMRI listed for use on organic crops; Evergreen does not have OMRI certification because it contains PBO (piperonyl butoxide), a synergist which improves kill • Highly toxic to bees exposed to direct treatment; do not apply on or drift onto blooming crops or weeds
spinosyns **(spinetoram & spinosad)** Entrust Blackhawk Radiant SC Entrust SC Spintor 2SC	 (a) 1 - 2 oz (b) 1.5 - 2 oz (a) 1.7-3.3 oz (b) 2.5 - 3.3 oz (a) 3 - 8 oz (b) 5 - 8 oz (a) 3 - 6 oz (b) 4.5 - 6 oz			a								b		28	• Maximum 12 oz / acre per year • Do not make more than two consecutive applications of products with spinetoram or spinosad • For European corn borer, sprays must target eggs and small larvae; see label for information on application timing • For thrips, control improved by adding an adjuvant; see label for details • Do not feed forage to meat or dairy animals

Active ingredient Trade Names	**Labelled rate per acre** (unless stated)	**aphids**	**BLB**	**ECB**	**grasshopper**	**GCW**	**MBB**	**PLH**	**spider mite**	**stink bug**	**TPB**	**thrips**	**WBC**	**Pre harvest interval (PHI) in days**	**Precautions and Remark**
spirotetramat Movento Movento HL	(a) 4 - 5 oz (a) 2 - 2.5 oz	a												7	• Movento label also lists 'suppression' of spider mites and some species of thrips
sulfoxaflor Transform WG	(a) 0.75-1.0 oz (b) 1.5 - 2.25 oz	a									b			7	• Translaminar product, which moves within the leaf to target sucking pests • Label also lists 'suppression' of thrips and some species of stink bug

Table 16. Potassium recommendations for selected yields of corn (mineral soils).

Soil test CEC	140 bu/a				180 bu/a			
	4	8	12	16	4	8	12	16
ppm	— lb K_2O/a —				— lb K_2O/a —			
40	92	115	142	173	103	126	153	184
80	44	59	78	101	55	70	89	112
85	38	52	70	92	49	63	81	103
95	38	38	54	74	49	49	65	85
105	38	38	38	56	49	49	49	67
115	38	38	38	38	49	49	49	49
125	19	38	38	38	25	49	49	49
135	0	19	38	38	0	25	49	49

Numbers highlighted are maintenance amounts .

Table 17. Potassium recommendations for selected yields of corn silage (mineral soils).

Soil test CEC	20 t/a				30 t/a			
	4	8	12	16	4	8	12	16
ppm	— lb K_2O/a —				— lb K_2O/a —			
40	214	237	264	295	294	300	300	300
80	166	181	200	223	246	261	280	300
85	160	174	192	214	240	254	272	294
95	160	160	176	196	240	240	256	276
105	160	160	160	178	240	240	240	258
115	160	160	160	160	240	240	240	240
125	80	160	160	160	120	240	240	240
135	0	80	160	160	0	120	240	240

Numbers highlighted are maintenance amounts .
Maximum annual recommendation is 300 lb K_2O/a.

Where soybeans have not been grown recently, inoculation of the soybean seed with soybean-specific Bradyrhizobia strains is essential for effective nitrogen fixation.

Soybeans are more sensitive to fertilizer placement and rate than corn . Starter fertilizer placed 2 inches to the side and 2 inches below the seed can contain up to 100 pounds of phosphate (P_2O_5) and 60 pounds of potash (K_2O) per acre . Placement of fertilizer with the seed may cause serious injury and reduced plant stands . When soybeans are drilled (7- to 10-inch spacing), broadcast and incorporate all the P_2O_5 and K_2O before planting . The P_2O_5 and K_2O required for soybeans may also be broadcast prior to the previous corn crop . For no-till soybeans, use a band-placed starter fertilizer or broadcast the required fertilizer before planting . On lake-bed soils and dark-colored soils where the soil pH is above 6.5, Mn application will usually improve soybean growth and yields. Include 2 lb Mn/a (or the recommended amount based on a soil test) in the starter fertilizer, or apply one or two applications of 1 to 2 lb Mn/a to the foliage. Broadcast applications made to the soil are not effective.

Table 18. Phosphorus recommendations for selected yields of soybean (mineral soils).

Soil test	Yield (bu/a)	
	40	60
ppm	— lb P_2O_5/a —	
5	82	98
10	57	73
15-30	32	48
35	16	24
40	0	0

Dry Edible (Field) Beans

Phosphorus and K recommendations are given in Tables 20 and 21.

Dry beans, like soybeans, are legumes and can fix N . Nitrogen fixation in dry bean can be unreliable, however, because of environmental conditions and variability among varieties . Therefore, applying 40 to 60 lb N/a is recommended to achieve maximum yield . Apply 60 lb N/a for beans grown in narrow rows (less than 23 inches) and for colored beans grown under irrigation . For beans grown with less intense management systems, apply 40 lb N/a . Applying ex-

Table 19. Potassium recommendations for selected yields of soybean.

Soil	40 bu/a				60 bu/a			
test CEC	4	8	12	16	4	8	12	16
ppm	— lb K_2O/a —				— lb K_2O/a —			
40	110	133	160	191	138	161	188	219
80	62	77	96	119	90	105	124	147
85	56	70	88	110	84	98	116	138
95	56	56	72	92	84	84	100	120
105	56	56	56	74	84	84	84	102
115	56	56	56	56	84	84	84	84
125	28	56	56	56	42	84	84	84
135	0	28	56	56	0	42	84	84

Numbers highlighted are maintenance amounts.

Table 20. Phosphorus recommendations for selected yields of dry edible beans (mineral soils).

Soil test	Yield (cwt/a)	
	20	30
ppm	— lb P_2O_5/a —	
5	74	86
10	49	61
15-40	24	36
45	12	18
50	0	0

Table 21. Potassium recommendations for selected yields of dry beans (mineral soils).

Soil	20 cwt/a				30 cwt/a			
test CEC	4	8	12	16	4	8	12	16
ppm	— lb K_2O/a —				— lb K_2O/a —			
40	86	109	136	167	102	125	152	183
80	38	53	72	95	54	69	88	111
85	32	46	64	86	48	62	80	102
95	32	32	48	68	48	48	64	84
105	32	32	32	50	48	48	48	66
115	32	32	32	32	48	48	48	48
125	16	32	32	32	24	48	48	48
135	0	16	32	32	0	24	48	48

Numbers highlighted are maintenance amounts.

cess N can delay bean maturity and may increase potential for white mold if the crop canopy is dense.

Dry beans are sensitive to low levels of available Zn . Providing adequate amounts of Zn fertilizer, if needed, is important because even mild Zn deficiency can delay maturity. Use a soil test to determine available Zn levels, and calculate the amount to apply from the equation on page 27 . In the absence of a soil test, apply 1 lb Zn/a if the previous crop was sugar beets or if the soil pH is above 6.5.

Dry beans do not tolerate fertilizer applied with the seed. Up to 40 lb N/a, all of the P_2O_5 and 60 lb of K_2O/a may be included in a starter fertilizer placed in a band 2 inches to the side and 2 inches below the seed . Before planting, broadcast and incorporate any additional fertilizer that is needed . Additional N may also be sidedressed two weeks after planting .

Bean yield may be affected by nutrient management and cropping systems. Dry beans grown after sugar beets often experience Zn deficiency, which results in delayed maturity and reduced yield . Dry beans rely on a symbiotic relationship with mycorrhizal fungi to assist the plant in taking up nutrients . Sugar beets do not host these fungi. Reduced numbers of mycorrhizae after sugar beets result in Zn deficiency because the bean plant can not take up enough Zn on its own .

Dry beans are also more sensitive to soil compaction than some other crops, particularly soybean . So take care to avoid soil compaction after primary tillage .

PRAB Production Practices Survey

1. **Open the camera on your smartphone**
2. **Hold it over the QR code below**
3. **Click on the link that appears at the top of the screen**
4. **Complete the survey on dry bean production practices and help direct future research!**

Thank you!

Michigan Dry Edible Bean Production Research Advisory Board

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