MICHIGAN DRY BEAN RESEARCH REPORT

2023

MSU Extension

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Production Research Advisory Board

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Validation of Improved Dry Bean Varieties, Maturities, and Integrated Weed Management Systems: PHASE II Managing Production for an Evolving Marketplace

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In 2022 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: *'Validation of Improved Dry Bean Varieties, Maturities, and Integrated Weed Management Systems: PHASE II Managing Production for an Evolving Marketplace'***.** 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)** Develop 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 2023 dry bean crop were very good. The state of Michigan received below average rainfall in the months leading up to dry bean planting in June, this resulted in lower-than-average levels of soil moisture at planting compared to a 5-year average. Weather stations place at MBS Airport indicated the 5th driest May and June on record. However, moisture was sufficient for planting and germination of the 2023 dry bean crop. Into July weather patterns took a major shift, weather stations at MBS airport reported the wettest July on record. This trend continued through the month of August. The rainfall did have damaging effects on low lying areas and a minor percentage of the overall crop was lost due to flooding. However, the now plentiful levels of soil moisture were highly favorable for pod set and fill. Limiting factors though midseason included the development of white mold disease. This fungal pathogen was present on nearly a statewide basis, but overall severity was low due to proactive fungicide programs and the improved genetic tolerance of current varieties. Anthracnose disease could also be found in quite high incidence throughout Huron County and should be a point of concern as we look forward to 2024 with high levels of inoculum left in the field following 2023 harvest. Overall cool and wet conditions delayed harvest by 7-10 days, with the majority of harvest beginning in late September and concluding in Mid-October. In general, dry bean yields were average to above average with excellent quality. USDA has reported a state average yield for 2023 of 24.1 cwt./acre when averaged across all dry bean classes.

We would like to thank all cooperators that hosted trials in 2023. Without their assistance, this research would not be possible.

Thank you,

Scott Bales & *Joe Cramer*

Introduction

In 2023, Michigan State University researchers and Michigan dry bean producers tested 151 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.

Small- and medium-seeded beans were tested in Bay, Huron, Sanilac, and Tuscola counties. Large-seeded beans were tested in Montcalm and Tuscola County.

This report summarizes the results of the trials including processing quality. Please contact Scott Bales (email balessco@msu.edu) with questions about the 2023 performance trials and suggestions for the 2024 trials.

Table 1. 2023 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	Spartan Acres	May 24	45	2x2	1,913	13.6"
Huron	Gruehn Farms	June 1	60	Broadcast	1,791	13.2"
Montcalm	Waldron Farms	May 31	85	2x2 Followed by Topdress	1,823	15.6" + irrigation
Sanilac	Shaw Farms	May 31	60	Broadcast	1,816	9.6"
Tuscola	Saginaw Valley Research and Extension Center	June 2	45	Broadcast	1,870	13.8"

Note. Weather data was retrieved from the nearest Michigan Automated Weather Network (MAWN) and the MSU Enviroweather station nearest to the trial. 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 24′ 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 [Table 2], pest loads, and variability in soil textures.)

Trials received industry standard seed treatments, fertilization, and weed control applications at labeled rates. 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 five 2023 performance trial locations, including the percentage of organic matter, soil type, soil pH, and soil cation exchange capacity (CEC). All macro- and micronutrients were sufficient for dry bean production.

Location	Percentage of Organic Matter	Soil Type	Soil pH	Soil CEC
Bay	2.4	Sandy Clay Loam	7.0	11.2
Huron	4.8	Sandy Loam	7.5	19.0
Montcalm	1.9	Sandy Loam	6.7	5.3
Sanilac	4.6	Sandy Clay Loam	7.8	18.6
Tuscola	3.3	Clay	7.1	19.3

Yield Results

Tables 5 through 14 provide agronomic information such as plant maturity. Plant maturity is rated visually in days after planting (DAP) for all locations. 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 2023 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 5) includes data from 2021, 2022, and 2023 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.

Table 15 lists the sources of the dry bean varieties tested in 2023. The entries are organized by bean market class.

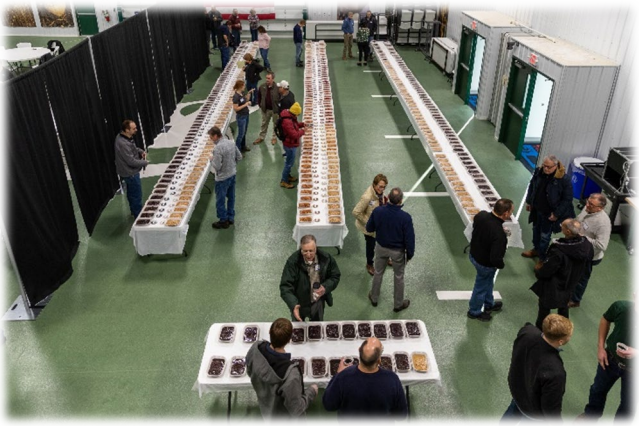
Canning Methods

All 151 lines tested were sampled for canning quality. For Mesoamerican germplasm (black, navy, small red, etc) samples were taken from Bay and Huron Trial locations, Andean germplasm was sampled from the Montcalm and Tuscola Trial location. Samples were processed utilizing the following methods: Each can was filled with 90 grams of dry matter for all mesoamerican market classes. Andean beans were filled to 85 grams of dry matter per can. Moisture levels prior to soaking ranged from 11.1-18.9% averaging at 14.9% 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 2024. Dry beans were soaked and blanched by market class according to the protocol in Table 3. Water for soaking included 125ppm of CaCl2 for Andean beans. Immediately following blanching samples were transferred to individually identifiable cans (size 307x407) and filled with 190ºF 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 2 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 (190ºF)	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 January 25, 2024 a public meeting was held for the evaluation of all lines tested. Cans were opened and scored by a 15-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 2024. 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.



Images from Annual Can Opening Meeting at Saginaw Valley Research and Extension Center

Table 4. General appearance scale used for scoring 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)	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	101	3,538	4,008**	3,320*	2,335	3,357*	3,058	3,112	3.2	1.8	2,265
13057	99	3,412	3,407*	2,998	1,714	2,703	NA	NA	3.8	2.3	2,397
14075	99	2,778	2,770	2,587	2,934*	2,952*	2,748	NA	2.2	1.5	2,419
14078	102	3,666*	3,315*	3,238*	1,791	2,976*	2,990	2,947	3.0	1.8	2,260
14084	101	3,337	3,384*	2,999	1,997	3,079*	2,878	2,873	3.5	1.8	2,346
Argosy	102	2,818	3,110*	3,412*	2,344	2,766	2,648	2,839	1.8	1.2	2,087
Armada	100	3,901*	3,569*	2,966	2,553*	3,349*	3,000	3,052	3.0	2.3	2,154
AuSable	97	3,373	2,713	2,098	1,849	2,730	2,582	2,821	2.8	2.3	2,381
Blizzard	100	3,755*	3,552*	3,817*	2,225	3,361*	2,913	3,045	2.8	2.7	2,325
Charm	102	3,507	3,605*	3,138	3,358**	3,340*	NA	NA	2.0	1.2	2,032
EX1802-N	96	2,350	2,852	2,344	1,571	2,330	2,214	2,263	2.7	2.0	2,520
EX1803-N	96	2,787	2,006	2,082	1,293	2,199	2,093	2,180	3.3	2.3	2,223
EX2109-N	98	2,999	3,302*	1,845	1,546	2,512	2,389	NA	2.7	1.8	2,065
EX2110-N	100	2,671	2,640	1,983	1,338	2,479	NA	NA	2.2	1.8	2,488
EX2111-N	99	3,194	2,539	2,076	2,057	2,492	NA	NA	2.2	1.8	2,554
HMS Bounty	101	4,483**	3,290*	3,180	3,229*	3,365*	3,259*	3,296*	2.5	2.5	2,433
HMS Medalist	102	3,660*	3,731*	3,487*	2,905*	3,473*	3,227	3,210	3.7	3.7	2,578
Liberty	102	4,114*	3,380*	3,005	3,089*	3,425*	3,364**	3,365**	3.8	2.7	2,348
N19246	97	3,155	1,947	2,606	2,426	2,327	2,728	2,903	3.5	1.5	2,462
N20395	100	2,914	3,069*	2,554	2,231	2,598	2,873	NA	3.3	1.3	2,540
N21510	100	3,297	3,436*	2,844	2,374	2,944*	NA	NA	2.3	2.3	2,602
N21526	98	3,263	2,869	2,711	2,151	2,889	NA	NA	3.0	1.8	2,771
N21532	98	3,015	3,485*	2,527	2,373	2,865	NA	NA	3.0	2.0	2,602
N22616	100	3,291	3,412*	3,183	2,229	3,154*	NA	NA	3.0	1.5	2,594
N22630	98	2,577	3,163*	2,699	2,003	2,497	NA	NA	2.2	2.0	2,747
Nautica	101	3,573	2,557	2,634	3,093*	2,858	2,676	2,866	2.3	1.8	2,583
ND Polar	102	3,308	2,145	2,414	1,984	2,232	2,571	NA	3.7	2.2	2,572
OAC Seal	102	3,028	3,280*	2,832	2,689*	2,928*	NA	NA	1.5	1.7	2,092
Rogue	100	3,644*	3,255*	3,071	2,636*	3,139*	2,755	2,953	3.5	2.7	2,439
SV1893GH	103	3,794*	2,628	2,905	2,594*	3,111*	2,781	3,015	3.0	2.0	2,164
T9905	102	3,476	2,655	2,942	2,426	2,881	2,557	NA	2.2	1.7	2,100
Valiant	99	3,537	3,766*	3,247*	2,725*	3,156*	3,029	2,975	3.8	3.0	2,312
Victory	99	3,578	3,935*	3,852**	2,982*	3,477**	3,087	3,148	3.0	2.2	2,257
Vigilant	96	3,197	2,798	2,171	2,535*	2,714	2,664	2,767	3.7	2.7	2,432
MEAN:	100	3,334	3,126	2,833	2,326	2,928	2,795	2,928	2.9	2.0	2,387
$LSD_{(0.05)}$:	NA	599	655	284	924	561	118	142	NA	NA	NA
CV:	NA	15.30%	17.80%	14.10%	19.50%	19.40%	10.00%	14.10%	NA	NA	NA

Note. The **highest** yield in each yield column and the **lowest** infection percentage in the white mold infection column are marked with two asterisks. Any values in a column that are not statistically different from the column's two-asterisk entry are marked with one asterisk.

[a] NA = Not available.

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

ENTRY	Maturity *(DAP)*	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	2,466	3,450	3,246	2,859*	2,796	2,966	2,990	3.0 (3.5)[a]	3.3 (3.5)	2,408
15655	103	2,753	3,708	3,175	3,372*	3,180	NA[b]	NA	3.5 (2.7)	3.5 (2.5)	2,253
16594	102	2,544	3,427	2,958	2,595	3,084	NA	NA	2.2 (2.5)	2.8 (2.8)	2,454
16598	102	3,223*	4,051	3,373	2,993*	3,305	3,249	NA	1.8 (3.0)	2.3 (2.8)	2,132
17751	101	2,651	3,912	3,283	2,516	3,152	3,310*	3,365*	3.5 (1.5)	3.5 (1.2)	2,124
B18094173	100	3,023*	4,594*	4,069*	2,928*	3,226	3,382*	NA	3.5 (4.0)	4.0 (4.2)	2,009
B1904-3-1	101	3,282*	3,740	3,803*	3,106*	3,571*	NA	NA	3.5 (2.8)	3.7 (2.7)	2,397
B19309	100	2,516	3,848	3,584*	2,737*	3,202	3,201	3,304*	3.2 (2.8)	4.0 (2.8)	2,302
B20536	102	2,738	4,648*	3,262	2,405	3,264	3,312*	NA	3.5 (3.2)	3.7 (3.3)	2,076
B20591	100	2,413	4,362*	3,604*	2,854*	3,471	3,032	3,288*	3.7 (2.8)	3.8 (2.7)	2,254
B20599	100	2,781	4,780**	3,472	3,278*	3,268	3,363*	NA	3.5 (3.7)	3.5 (3.2)	2,267
B21710	101	3,030*	3,672	2,821	3,324*	3,522*	3,037	NA	3.0 (2.7)	3.5 (2.7)	2,359
B22003	101	2,852	3,786	3,571*	1,728	2,859	NA	NA	3.8 (3.7)	4.5 (4.3)	2,245
B22041	99	3,345*	4,596*	3,189	2,828*	3,768*	NA	NA	4.2 (3.7)	3.7 (3.7)	2,316
B22854	99	2,666	3,749	3,268	3,031*	3,154	NA	NA	3.7 (3.0)	4.0 (3.2)	2,030
B3035411	99	2,621	3,688	3,696*	2,625	3,071	3,147	NA	2.7 (2.7)	3.3 (3.0)	2,154
B4062257	101	2,086	3,662	3,329	2,775*	3,007	NA	NA	3.2 (2.8)	3.7 (3.0)	2,152
B5054313	100	2,682	4,295*	3,438	2,832*	3,467	NA	NA	2.8 (3.2)	3.7 (3.2)	2,073
B7071259	97	3,795*	4,473*	3,363	3,183*	3,861**	3,570**	NA	4.2 (3.3)	3.5 (2.7)	2,102
B7072252	99	2,874	4,564*	4,235**	2,762*	3,372	NA	NA	3.3 (4.0)	3.7 (3.7)	2,153
B7072269	98	2,953*	4,224	3,394	2,668*	3,200	3,202	NA	3.7 (4.3)	3.7 (4.2)	2,231
Bannock	101	1,967	4,125	3,909*	2,275	3,193	NA	NA	3.3 (2.7)	3.3 (2.5)	2,076
Black Bear	105	3,642*	3,952	3,308	2,919*	3,361	3,403*	3,247*	2.3 (2.3)	2.7 (2.5)	2,323
Black Pearl	100	2,517	3,352	3,302	2,359	2,829	2,988	3,181*	3.3 (4.8)	3.8 (4.7)	2,158
Black Tails	102	3,016*	3,141	2,259	2,767*	2,632	2,792	2,847	2.7 (3.2)	2.8 (3.5)	2,122
BlackBeard	103	3,816*	4,369*	3,732*	3,507**	3,653*	3,324*	3,326*	3.7 (4.5)	3.8 (3.8)	1,983
Eclipse	98	1,955	3,464	2,898	2,331	2,582	NA	NA	3.2 (2.3)	2.7 (2.3)	2,215
ND Twilight	96	2,457	2,799	2,849	1,759	2,543	2,207	2,428	2.8 (2.0)	2.8 (2.2)	2,242
Nimbus	103	3,833**	3,728	3,417	2,562	3,293	3,462*	3,391**	3.0 (2.2)	3.7 (2.0)	2,201
Spectre	105	3,052*	3,643	3,211	2,704*	3,141	3,148	3,155*	2.5 (3.2)	2.8 (2.8)	2,136
Umbra	105	2,307	4,270	3,358	3,030*	3,364	NA	NA	3.0 (3.0)	3.7 (3.5)	1,885
Zenith	100	2,417	3,645	2,777	2,189	2,884	3,018	3,150*	4.0 (4.5)	3.8 (4.3)	2,202
MEAN:	100	2,822	3,929	3,348	2,744	3,197	3,156	3,139	3.2 (3.1)	3.1 (3.5)	2,189
$LSD_{(0.05)}$:	NA	387	495	294	846	340	278	241	NA	NA	NA
CV:	NA	19.4%	10.7%	12.4%	18.1%	18.2%	17.9%	19.1%	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 scores followed by color. Example: appearance(color). [b]NA = Not available.

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

ENTRY	Maturity *(DAP)*	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	98	3,627*	3,594**	3,409*	2,847*	3,543*	3,061	3,149	2.3	2.8	1,229
17822	99	4,111*	2,905	3,310	2,735*	3,442	3,378*	NA	2.5	3.7	1,503
17837	100	4,291**	3,410*	3,899**	2,153	3,867**	3,088	3,087	2.0	3.7	1,363
17875	99	2,930	2,348	2,379	2,693*	2,553	2,725	2,899	1.8	3.3	1,261
19837	96	3,825*	2,738	3,618*	3,362**	3,393	3,180	NA	1.3	2.8	1,234
19857	101	3,833*	2,829	2,991	2,732*	3,218	NA	NA	1.8	2.3	1,402
Coral	102	3,703*	2,680	2,796	2,350*	3,060	2,854	2,853	1.2	3.3	1,272
R20653	103	4,220*	2,916	3,399*	2,757*	3,512	NA	NA	2.2	3.7	1,413
R20667	100	3,192	2,620	3,258	2,551*	3,024	2,846	2,992	2.8	3.5	1,456
R20669	102	4,225*	2,713	3,657*	3,271*	3,532*	3,552**	NA	1.5	3.7	1,497
R22092	99	3,339	3,026	2,791	2,748*	3,052	NA	NA	1.3	2.7	1,277
R22716	99	4,038*	2,178	2,436	3,018*	2,884	NA	NA	3.5	2.0	1,351
Viper	100	3,953*	3,230*	3,495*	2,566*	3,559*	3,408*	3,289**	3.8	1.3	1,577
MEAN:	100	3,791	2,861	3,188	2,752	3,280	3,121	3,045	2.2	3.0	1,372
$LSD_{(0.05)}$:	NA	819	386	557	1028	348	261	119	NA	NA	NA
CV:	NA	18.10%	11.30%	14.65%	20.97%	15.69%	18.99%	11.11%	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 (conventional and slow darkening) agronomic, yield and canning results.

ENTRY	Maturity (DAP)	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.)
Charro	101	2,554	3,812**	3,881*	3,393*	3,541*	3,442**	3,369**	4.7	4.3	1,133
EX2143-P	97	2,869	2,347	2,357	2,102	2,524	NA	NA	2.5	2.0	1,286
EX2145-P	97	3,420*	2,420	2,617	2,110	2,819	NA	NA	2.8	2.3	1,338
Gleam[†]	98	2,550	3,131	3,475	2,984*	3,052	NA	NA	2.7	4.2	1,374
Mystic[†]	98	2,913*	2,934	3,489	2,784	3,112	NA	NA	1.0	1.5	1,126
ND Falcon	101	2,307	2,887	2,577	2,422	2,591	2,691	2,679	3.3	4.0	1,227
ND Palomino[†]	99	3,233*	3,528*	4,111**	2,823*	3,624**	2,812	2,822	3.2	4.5	1,262
ND Rodeo[†]	100	3,698**	3,389	3,411	2,982*	3,499*	NA	NA	3.0	3.7	1,129
P19713	98	3,238*	3,265	3,736*	2,616	3,413*	3,273	3,263*	4.7	3.8	1,316
SV6139GR	98	3,209*	2,158	3,487	2,272	2,952	2,676	2,950	3.2	3.7	1,346
USDA Diamondback[†]	99	2,749	2,334	2,287	2,645	2,456	NA	NA	3.0	4.2	1,290
USDA Rattler	98	3,201*	3,150	2,557	3,222*	2,969	NA	NA	2.7	3.3	1,239
Vibrant[†]	98	3,253*	3,200	2,816	3,529**	3,090	NA	NA	2.8	2.5	1,248
MEAN:	99	3,015	2,966	3,139	2,760	3,040	2,911	3,017	3.0	3.4	1,255
$LSD_{(0.05)}$:	NA	792	327	583	735	319	158	191	NA	NA	NA
CV:	NA	22.02%	9.24%	15.56%	14.94%	15.50%	12.77%	18.41%	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.

[†]Slow darkening variety

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

ENTRY	Maturity *(DAP)*	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	96	3,208	2,273	2,187	2,000	2,417	2,322	2,337	2.8	2.2	1,247
Eiger	99	4,678**	3,139**	3,328**	2,462*	3,402**	3,195**	3,170*	2.7	1.5	1,318
G19613	99	4,148*	2,815*	2,233	2,213*	2,852	2,966*	3,097*	2.7	2.5	1,220
ND Pegasus	100	3,455	2,490	2,976*	2,483**	2,851	2,986*	3,178**	2.2	2.2	1,290
Powderhorn	94	2,407	2,663*	2,194	2,057*	2,330	2,417	2,521	3.5	3.3	1,351
MEAN:	98	3,579	2,676	2,584	2,243	2,770	2,777	2,860	2.8	2.3	1,285
LSD$_{(0.05)}$:	NA	904	530	461	474	291	273	195	NA	NA	NA
CV:	NA	20.06%	15.70%	14.17%	16.77%	17.76%	23.79%	20.21%	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)*	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)*	Montcalm Co. Canning Score *(1-5)*	Tuscola Co. Canning Score *(1-5)*	Seed Size *(Seeds/lb.)*
16756	92	3,558*	2,659	2,873	2,995	1,941	2,008	4.7	4.5	989
16758	89	2,789	1,858	2,606	2,871	1,321	1,599	3.8	4.3	996
16775	103	2,174	2,880	2,271	2,449	1,790	1,851	3.8	2.8	865
16816	92	3,041*	2,233	2,726	2,942	1,700	1,816	3.3	3.7	818
151093	104	3,901**	3,678	3,428**	3,512**	2,360*	2,527*	3.7	3.5	784
Amaranto	92	2,775	2,214	2,885	3,010	1,831	1,956	2.5	2.3	727
CR17-1-7-B2	105	1,709	3,626	NA	NA	NA	NA	2.8	3.3	670
Etna	98	3,239*	2,269	3,003	3,296*	1,688	1,913	1.8	2.3	729
Firestripe	100	3,317*	3,514	3,204*	NA	2,141*	NA	3.0	2.5	653
Jester	102	2,285	3,966**	2,459	2,802	2,617**	2,654**	2.3	2.2	698
Krimson	95	2,244	2,103	NA	NA	NA	NA	3.0	2.3	730
Navabi	102	2,475	1,758	2,811	NA	1,830	NA	1.2	1.5	751
MEAN:	97	2,748	2,630	2,827	2,985	1,922	2,040	3.0	2.9	784
LSD$_{(0.05)}$:	NA	436	1009	318	227	508	312	NA	NA	NA
CV:	NA	13.20%	27.48%	13.50%	11.23%	31.60%	22.55%	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 11. Light red kidney bean agronomic, yield and canning results.

ENTRY	Maturity *(DAP)*	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)*	Montcalm Co. Canning Score *(1-5)*	Tuscola Co. Canning Score *(1-5)*	Seed Size *(Seeds/lb.)*
11413	97	3,218*	1,744	3,272*	3,420*	1,849	2,109*	2.0	3.2	716
15916	95	2,811	2,368*	2,879	3,109	2,314*	2,416*	1.8	3.2	788
15923	98	3,458*	2,082*	3,333**	3,499**	1,431	1,771	2.0	4.2	779
16998	95	2,718	2,581*	2,790	3,086	2,088	2,219*	3.0	4.2	688
161082	97	3,088*	3,543*	3,239*	3,317*	2,597**	2,504**	1.8	3.2	731
Big Red	94	2,827	1,791	2,974	3,162	1,455	1,871	1.7	2.7	793
California Early	96	2,566	2,236*	2,839	2,904	1,876	1,902	1.3	2.7	740
K20743	98	2,718	3,014*	2,698	3,256*	2,176	2,491*	2.3	2.7	859
K22604	101	3,548**	3,607**	NA	NA	NA	NA	2.0	2.5	765
Pink Panther	99	3,043*	2,430*	3,091*	3,252*	1,916	2,029	2.2	2.5	733
Red Dawn	94	2,596	1,731	2,940	2,970	1,883	2,090*	1.3	1.8	738
Ronnie's Red	103	2,707	2,835*	3,034*	2,754	2,187*	2,447*	2.0	1.8	754
MEAN:	99	2,941	2,497	3,033*	3,156	1,979	2,168	2.0	2.9	757
$LSD_{(0.05)}$:	NA	509	926	329	270	601	422	NA	NA	NA
CV:	NA	14.47%	30.97%	12.78%	12.64%	36.47%	28.78%	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 12. Dark red kidney bean agronomic, yield, and canning results.

ENTRY	Maturity *(DAP)*	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)*	Montcalm Co. Canning Score *(1-5)*	Tuscola Co. Canning Score *(1-5)*	Seed Size *(Seeds/lb.)*
15977	100	1,741	1,963	2,192	2,656	1,672	2,029*	3.3	3.2	742
161156	100	2,506	1,895	2,736	3,069*	2,235*	2,327*	2.5	3.3	876
161165	94	2,832*	2,822**	NA	NA	NA	NA	2.3	3.5	757
181017	100	2,530	2,563*	3,036*	3,212**	2,499**	2,567**	3.7	4.0	779
181020	97	2,659	2,232*	2,720	2,856	1,447	1,664	1.8	2.3	780
181021	92	2,863*	2,393*	3,152*	2,896	1,635	1,858	2.5	3.8	821
DRK1601-1	95	1,835	2,015	NA	NA	NA	NA	2.8	2.3	820
Dynasty	99	2,627	2,663*	2,857	3,108*	2,424*	2,553*	1.7	3.0	726
Epic	101	3,197**	2,070	3,204**	3,178*	2,224*	2,363*	2.5	2.2	783
Gallantry	102	2,723*	2,643*	2,771	3,042*	1,949*	2,163*	3.5	4.5	952
Montcalm	100	2,834*	2,395*	2,839	2,773	2,072*	2,072*	3.8	3.0	841
ND Redbarn	102	2,357	1,586	NA	NA	NA	NA	2.8	2.8	867
Rampart	101	2,705*	2,165	2,899	3,033*	2,025*	2,229*	3.3	3.8	857
Red Hawk	98	2,451	2,514*	2,531	2,681	1,633	1,634	3.3	3.8	830
Seattle	101	2,310	2,501*	2,607	2,934*	2,332	2,358*	3.0	3.5	920
MEAN:	99	2,545	2,295	2,795	2,953	2,012	2,151	2.9	3.3	824
$LSD_{(0.05)}$:	NA	368	548	290	305	567	394	NA	NA	NA
CV:	NA	12.17%	19.80%	12.47%	15.30%	33.00%	27.10%	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 13. White kidney bean agronomic, yield, and canning results.

ENTRY	Maturity *(DAP)*	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)*	Montcalm Co. Canning Score *(1-5)*	Tuscola Co. Canning Score *(1-5)*	Seed Size *(Seeds/lb.)*
Beluga	104	2,321	3,090*	2,598	2,491	2,248	2,377	2.8	2.7	743
Denali	98	3,063*	2,869*	3,175*	3,194**	2,122	2,337	1.8	2.5	780
K19830	101	2,839*	3,091*	3,172*	3,109*	2,402*	2,698*	1.8	1.8	680
K19832	101	3,284*	3,221*	3,178*	NA	2,501	NA	2.2	2.5	678
ND Whitetail	101	2,266	3,032*	2,854	2,828	2,665*	2,707**	2.5	1.8	798
Snowdon	102	2,247	2,291	2,713	2,845	1,832	2,013	1.8	1.7	654
Snowshoe	104	2,794	3,163*	3,134*	NA	2,914**	NA	1.8	2.2	717
WK1601-1	102	3,303**	3,514**	3,236**	NA	2,534*	NA	3.5	3.3	821
MEAN:	101	2,764	3,034	3,008	2,893	2,402	2,426	2.3	2.3	734
$LSD_{(0.05)}$:	NA	486	889	523	343	567	262	NA	NA	NA
CV:	NA	14.46%	22.60%	20.78%	17.31%	28.19%	15.75%	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 14. Mayocoba/yellow bean agronomic, yield, and canning results.

ENTRY	Maturity *(DAP)*	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)*	Montcalm Co. Canning Score *(1-5)*	Tuscola Co. Canning Score *(1-5)*	Seed Size *(Seeds/lb.)*
Claim Jumper	103	2,445*	3,362**	2,338	2,501	2,717**	2,731**	3.3	4.0	1,189
Motherlode	102	2,220	2,818*	2,084	2,025	2,257	2,368	4.2	4.3	981
RRY1803-1-1	94	2,047	2,440	NA	NA	NA	NA	3.8	3.7	1,222
Y1608-14	99	2,153	1,790	2,263	2,340	1,838	1,880	2.5	3.0	1,228
Y1702-22	95	2,538*	2,312	2,811**	2,800**	1,802	1,949	1.7	2.0	1,209
Y19817	99	2,851*	3,096*	NA	NA	NA	NA	2.2	3.3	1,075
Yellowstone	98	2,856**	2,388	2,598*	2,611*	1,935	2,169	4.0	3.0	1,174
MEAN:	99	2,444	2,601	2,419	2,455	2,110	2,219	3.1	3.3	1,154
$LSD_{(0.05)}$:	NA	460	638	294	236	394	271	NA	NA	NA
CV:	NA	15.37%	19.94%	14.32%	14.05%	21.97%	17.85%	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.

2023 Sourcing Information

Table 15. Sources of dry bean entries tested in the 2023 performance trials, organized by market class.

Entry ID	Market Class	Source
15655	BL	ProVita
16594	BL	ProVita
16598	BL	ProVita
17751	BL	ProVita
15619	BL	ProVita
B18094173	BL	ADM
B1904-3-1	BL	USDA-ARS
B19309	BL	MSU
B20536	BL	MSU
B20591	BL	MSU
B20599	BL	MSU
B21710	BL	MSU
B22003	BL	MSU
B22041	BL	MSU
B22854	BL	MSU
B3035411	BL	ADM
B4062257	BL	ADM
B5054313	BL	ADM
B7071259	BL	ADM
B7072252	BL	ADM
B7072269	BL	ADM
Bannock	BL	Hensall Co-op
Black Bear	BL	ProVita
Black Pearl (B19344)	BL	MSU
Black Tails	BL	ProVita
BlackBeard (14506)	BL	ProVita
Eclipse	BL	NDSU
ND Twilight	BL	NDSU
Nimbus (14500)	BL	ProVita
Spectre (14497)	BL	ProVita
Umbra	BL	Hensall Co-op
Zenith	BL	MSU
16756	CR	ProVita
16758	CR	ProVita
16775	CR	ProVita
16816	CR	ProVita
151093	CR	ProVita
Amaranto	CR	Bayer
CR17-1-7-B2	CR	USDA-ARS
Etna	CR	Bayer

Entry ID	Market Class	Source
Firestripe	CR	TVS
Jester (151085)	CR	ProVita
Krimson	CR	TVS
Navabi	CR	TVS
15977	DRK	ProVita
161156	DRK	ProVita
161165	DRK	ProVita
181017	DRK	ProVita
181020	DRK	ProVita
181021	DRK	ProVita
DRK1601-1	DRK	USDA-ARS
Dynasty	DRK	Hensall Co-op
Epic	DRK	ProVita
Gallantry	DRK	Hensall Co-op
Montcalm	DRK	MSU
ND Redbarn	DRK	NDSU
Rampart (09434)	DRK	ProVita
Red Hawk	DRK	MSU
Seattle (151011)	DRK	ProVita
Aries	GN	ADM
Eiger	GN	MSU
G19613	GN	MSU
ND Pegasus	GN	NDSU
Powderhorn	GN	MSU
11413	LRK	ProVita
15916	LRK	ProVita
15923	LRK	ProVita
16998	LRK	ProVita
161082	LRK	ProVita
Big Red	LRK	ProVita
CELRK	LRK	TVS
K20743	LRK	MSU
K22604	LRK	MSU
Pink Panther	LRK	Bayer
Red Dawn (09363)	LRK	ProVita
Ronnie's Red	LRK	ProVita
Claim Jumper (13655)	MY	ProVita
Motherlode (191274)	MY	ProVita
RRY1803-1-1	MY	USDA-ARS
Y1608-14	MY	USDA-ARS

Entry ID	Market Class	Source
Y1702-22	MY	USDA-ARS
Y19817	MY	MSU
Yellowstone	MY	MSU
12039	NA	ProVita
13057	NA	ProVita
14075	NA	ProVita
14078	NA	ProVita
14084	NA	ProVita
Argosy	NA	Hensall Co-op
Armada (13068)	NA	ProVita
AuSable (N18103)	NA	MSU
Blizzard	NA	ProVita
Charm	NA	TVS
EX1802-N	NA	TVS
EX1803-N	NA	TVS
EX2109-N	NA	TVS
EX2110-N	NA	TVS
EX2111-N	NA	TVS
HMS Bounty (12047)	NA	ProVita
HMS Medalist	NA	ProVita
Liberty (15095)	NA	ProVita
N19246	NA	MSU
N20395	NA	MSU
N21510	NA	MSU
N21526	NA	MSU
N21532	NA	MSU
N22616	NA	MSU
N22630	NA	MSU
Nautica	NA	Hensall Co-op
ND Polar	NA	NDSU
OAC Seal	NA	Jefferies Seeds
Rogue	NA	Hensall Co-op
SV1893GH	NA	Bayer
T9905	NA	TVS
Valiant (08077)	NA	ProVita
Victory (15094)	NA	ProVita
Vigilant	NA	ADM
Charro	P	MSU
EX2143-P	P	TVS
EX2145-P	P	TVS
ND Falcon	P	NDSU

Entry ID	Market Class	Source
P19713	P	MSU
SV6139GR	P	Bayer
USDA Rattler	P	Kelly Bean
Coral	PI	MSU
Gleam	SDP	ProVita
Mystic	SDP	ProVita
ND Palomino	SDP	NDSU
ND Rodeo	SDP	NDSU
USDA Diamondback	SDP	Kelly Bean
Vibrant	SDP	ProVita
16686	SR	ProVita
17822	SR	ProVita
17837	SR	ProVita
17875	SR	ProVita
19837	SR	ProVita
19857	SR	ProVita
R20653	SR	MSU
R20667	SR	MSU
R20669	SR	MSU
R22092	SR	MSU
R22716	SR	MSU
Viper	SR	ProVita
Beluga	WK	MSU
Denali	WK	MSU
K19830	WK	MSU
K19832	WK	MSU
ND Whitetail	WK	NDSU
Snowdon	WK	MSU
Snowshoe	WK	TVS
WK1601-1	WK	USDA-ARS

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, SDP = slow darkening pinto, 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 3 of 3)

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Introduction:

Black beans are one of the most important dry bean market classes in North America. Year after year, 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 the black bean market class. Black bean color is derived from anthocyanins present in the seed coat; however, anthocyanins are highly water soluble and can readily leach into the water or brine during processing. This can leave the end-product a light shade of brown or red 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 (hydration, splits, and texture). As the industry advances and looks to continue meeting the trend of increased demand, it is essential that we understand processing quality of newly adopted varieties in this market class and how they compare to current market standards. Identification and validation of unique quality characteristics in commercial black beans is essential for the success of the entire dry bean supply chain.

Materials and Methods:

Six black bean varieties were selected for testing: Adams, Black Beard, Nimbus, Spectre, Zenith, and Zorro. 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 six varieties were planted at two separate locations in Michigan in 2020, 2021, and 2022. These locations were all planted in research trials that took place within fields of commercial production. All locations are in the traditional dry bean production region of Michigan comprised of the Thumb and Saginaw Valley. Dry beans were seeded at 105,000 seeds per acre in a plot size of 6.6'x24'. 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 all in very late May or early June depending on year or location. This is standard for dry bean production in Michigan. Since differing county locations were used between year 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 utilizing a Wintersteiger Quantum combine on in September of all years. Moisture adjusted yield was taken on cleaned seed from each plot and used to calculate yield per acre in pounds at 18% moisture.

Dry bean samples were then canned using a standard research protocol developed at MSU (Wang, et al., 2021). Three field replicates from each variety were used to create individual canning replications for each variety within a location. For each replicate, a 115-g solid sample was taken. Black bean samples were than blanched for 90 seconds in a steam kettle at 190ºF in tap water. Hydration coefficients (HC) were than calculated as the ratio of sample weight after blanching to the weight of the original dry seed. The blanched beans were than 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 250ºF 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 (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. Color was visually scored separately on a 5-point scale with 5 = most black and 1= least black canned seed color. 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. All colors were measured, but for the purpose of black bean evaluations just L* is presented in results in *Table 1*. 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 black beans are between 55 and 65 kg with higher values indicating 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 α=0.05, when insignificant data were pooled over insignificant factors.

Results and Discussion:

Overall yield and first pass quality was average to slightly above average for both locations in all years of testing compared to a 5-year average. Table 1 and 2 contain all numeric results for black beans. Tables 3 is the ANOVA (analysis of variance) table for all variables measured. 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 bean yields were statistically different for multiple interactions between factors (Table 3). When means were separated for the interaction of most interest (Variety * Year) little differences existed between varieties in yield potential with the exception of Zorro, such that Zorro trended to produce yields lower than the other five entries tested. When combined over locations, seed weight ranged from 1744-2388 seeds per pound. Most measurements of canned bean quality were statistically significant for the interaction of Variety* Location* Year (three-way interaction). This includes hydration coefficients (HC) or the ratio of blanched seed weight (90 second blanch) to the original dry seed weight. Numerically, HC were greatest from Black Beard at 1.36 in the East growing location in 2021 (Table 1). However, all HC ratios ranged between 1.05-1.36 with the varieties of Black Beard, Spectre, and Nimbus grouping in the top statistical group in at least one Location by Year interaction. Black bean color was evaluated by visual ratings by trained evaluators and empirically using a colorimeter. Both methods of evaluation produced a three-way interaction as previously described. 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) of varieties separated into two general groups. Dark: Zenith and Black Beard (lowest L* values: 12.9-17.1); Medium: Zorro, Spectre, Nimbus and Adams (16.7-20.6). In a similar response to visual color ratings, appearance ratings were also impacted by the same three-way interaction. Overall, all varieties scored as average (3.0-4.0) in at least one location by year

combination (Table 1). However, except for Zenith, below average scores were also noted in specific locations by years combinations for all varieties.

Conclusions:

From 2020-2022 results, it appears that new varieties in the black bean market class have maintained commercially acceptable canning quality while surpassing historical market standards for yield (Zorro). However, when analyzing comprehensive measurements of canning quality, it becomes apparent that high levels of variability exist as a result of the production environment. This is a significant challenge for the canning industry when consistent quality/canned bean products are the goal. Future efforts in variety development will need to focus on the stability of canning traits across complex environments not only in Michigan, but across North America if we are to make progress on the overall improvement and consistency of canning quality.

We would like to thank Bush Brothers Company (Knoxville, Tennessee) and the Michigan Bean Commission for supporting this research.

Table 1. Black bean phenotypic results for the 2020, 2021, and 2022 field seasons*.

		HC[1]		WDC[2]		Texture[3]		Color[4]		Appearance[5]		L*[6]	
Variety	***Year***	East[7]	West	East	West	East	West	East	West	East	West	East	West
Adams	*2020*	1.11 ac	1.16 af	179.3 em	173.4 cj	69.37 dh	71.10 ei	2.6 cf	3.0 dg	2.8 bi	3.2 cj	17.80 cl	16.74 bi
	2021	1.19 bg	1.16 af	202.9 ko	203.1 lo	49.77 a	55.06 ac	3.1 dg	3.0 dg	3.9 fj	4.2 ij	19.90 im	19.70 hm
	2022	1.11 ad	1.15 af	163.4 ai	160.2 ah	66.05 cg	59.07 ad	1.7 ac	1.3 ab	1.7 ab	2.7 bh	19.80 im	20.94 lm
Black Beard	*2020*	1.05 a	1.19 bg	184.8 hm	183.0 fm	77.12 gi	69.29 dh	4.6 jk	4.0 gk	3.7 ej	2.9 bi	12.96 a	14.35 ac
	2021	1.36 h	1.18 bg	172.7 bi	206.3 mo	56.21 ac	54.79 ac	4.9 k	4.8 k	3.8 ej	4.6 j	16.11 ag	16.17 ah
	2022	1.10 ac	1.19 bg	163.8 ai	148.3 ac	73.91 ei	76.51 fi	4.7 k	4.3 ik	3.3 dj	3.7 ej	15.40 ad	16.02 ag
Nimbus	*2020*	1.10 ac	1.20 cg	171.9 bi	159.3 ah	74.91 ei	80.93 i	3.2 eh	3.2 eh	3.5 ej	3.0 bi	16.98 cj	17.65 cl
	2021	1.30 gh	1.29 gh	173.2 bj	185.2 hm	54.54 ac	53.60 ab	2.2 be	2.6 cf	2.4 ag	3.8 ej	19.94 im	21.18 lm
	2022	1.16 af	1.21 cg	146.3 ab	148.6 ac	79.34 hi	74.66 ei	1.7 ac	1.0 a	2.0 ad	1.0 a	17.84 cl	19.55 gm
Spectre	*2020*	1.08 ab	1.20 cg	177.0 dl	181.8 em	76.32 fi	69.32 dh	2.3 be	2.6 cf	2.9 bi	1.9 ad	16.43 ai	17.20 ck
	2021	1.25 eh	1.23 dg	185.7 hm	200.1 jo	55.85 ac	58.87 ad	2.9 dg	3.5 fj	1.8 ac	4.2 ij	20.62 km	20.44 jm
	2022	1.12 ad	1.25 eh	159.9 ah	144.1 a	71.49 ei	69.66 di	3.0 dg	2.0 ad	2.3 ae	1.7 ab	18.23 dm	19.16 fm
Zenith	*2020*	1.15 af	1.21 cg	188.7 in	175.7 dk	64.07 be	68.62 dh	4.6 k	4.2 hk	3.9 gj	3.3 cj	13.31 ab	13.33 ab
	2021	1.23 dg	1.16 af	206.5 mo	219.7 o	49.98 a	51.30 a	4.8 k	4.8 k	4.1 hj	4.1 hj	15.38 ad	17.18 ck
	2022	1.12 ad	1.21 cg	155.2 ae	150.3 ad	65.31 cf	65.66 cg	5.0 k	4.3 ik	4.0 hj	3.3 dj	16.36 ai	15.51 ae
Zorro	*2020*	1.14 ae	1.18 bg	184.3 hm	173.2 bi	75.97 fi	71.78 eh	2.9 dg	4.2 hk	2.4 af	3.7 ej	16.61 bi	15.90 af
	2021	1.26 fh	1.20 cg	183.9 gm	214.2 no	56.71 ac	52.51 ab	3.3 ei	3.5 fj	3.3 dj	4.0 hj	18.22 dm	21.49 m
	2022	1.16 af	1.21 cg	157.1 ag	156.2 af	72.48 ei	71.40 ei	3.0 dg	2.7 cf	3.7 ej	3.3 dj	19.01 em	18.29 dm

[1] HC (hydration coefficient): the ratio of the weight of blanched seed to dry seed

[2] WDC (washed drained weight coefficient): the ratio of the weight of rinsed and drained canned seed to the blanched seed weight

[3] Texture is measured on canned beans as force (kg) required to crush the sample

[4] Visual evaluation of color on a scale from 1-5 (1=least black, 5=most black)

[5] Appearance the canned bean sample on a scale from 1-5 (1=unacceptable, 5=exceptional)

[6] L*: CIE Lab color scale, where L* represents lightness

[7] Western locations refer to Bay Co. in 2020-2022 Eastern locations include Tuscola Co. in 2020 and Huron Co. in 2021 &2022.

* Means followed by the same letter are not significantly different (α=0.05)

Table 2. Black bean agronomic results for the 2020, 2021 and 2022 field season*.

Variety	Year	Maturity[1]	Days to Flower[2]	Yield[3]	Seed Size
		– dap –	*– dap –*	*–Lb. A^{-1}–*	*seeds Lb^{-1}*
Adams	2020	101	44	3104 ac	2066
	2021	91	45	3407 ab	2013
	2022	101	46	2828 ac	2023
Black Beard	2020	100	47	3136 ac	1967
	2021	91	46	3151 ac	1917
	2022	101	46	2833 ac	1802
Nimbus	2020	101	46	3373 ac	1915
	2021	91	46	3074 ac	1967
	2022	101	47	3437 a	1916
Spectre	2020	101	45	3166 ac	2032
	2021	93	45	2998 ac	2118
	2022	102	48	2985 ac	1744
Zenith	2020	101	46	2755 ac	2034
	2021	91	45	3231 ac	1900
	2022	100	46	3039 ac	1749
Zorro	2020	100	45	2695 c	2388
	2021	91	44	3010 ac	1933
	2022	99	47	2713 bc	1963

[1] Dry bean maturity averaged across locations as 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.

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

Measurement	**Factor A (Variety)**	**Factor B (Location)**	**Factor C (Year)**	**Interaction (A*B)**	**Interaction (A*C)**	**Interaction (B*C)**	**Interaction (A*B*C)**
Yield	0.002	NS	NS	0.02	0.02	<0.0001	NS
Hydration coefficient (HC)	NS	NS	<0.0001	NS	<0.0001	<0.0001	0.0031
Washed drained weight coefficient (DWC)	<0.0001	0.0013	<0.0001	NS	0.0090	NS	0.0004
Texture	<0.0001	NS	<0.0001	NS	0.0021	NS	0.0051
Color (Visual)	<0.0001	NS	<0.0001	0.0153	<0.0001	0.0007	0.0067
Appearance	<0.0001	0.0404	<0.0001	0.0103	0.0001	0.0002	0.0002
L*	<0.0001	0.0253	<0.0001	NS	NS	NS	0.0451
a*	<0.0001	NS	<0.0001	0.0370	<0.0001	0.0443	NS
b*	<0.0001	0.0180	<0.0001	0.0386	<0.0001	0.0156	0.0200

2023 Irrigated Variety Trial

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Location: Crystal, MI (May 31, 2023)	**Treated Plot Size:** 6.6' x 25'
Replicated: 4 times	**Row Width:** 20-inch
Design: RCBD	**Population:** 105,000 seeds/A
Nitrogen Rate: 85 lb./A Total (2x2) Fb . Topdress	**Total GDD:** 1823
Cooperator: Waldron Farms	**Total Precipitation:** 15.6" + Irrigation
Soil Type: Sandy Loam (1.8% OM, 5.3 CEC)	**Fungicide Applications:** None
PPI *May 30, 2023:* Eptam (3 pt) + Sonalan (1.5 pt)	
POST A *June 22, 2023:* Basagran (20 fl oz) + COC (1% v/v) + Max-in ZMB (16 fl oz)	
POST B *June 28, 2023*: Varisto (21 fl oz) + Reflex (8 fl oz) + Outlook (10 fl oz) + COC (1% v/v) + AMS (17 lb./100 gal)	

Table 1. Variety name, market class, yield rank (1-12), and dry bean yield.

#	Name	Market Class	Yield Rank	Yield *
1	Spectre	Black	1	2879**
2	Zenith	Black	2	2502*
3	Liberty	Navy	3	2383
4	Black Beard	Black	4	2055
5	Coral	Pink	5	1881
6	AuSable	Navy	6	1677
7	ND Pegasus	Great Northern	7	1632
8	Black Pearl	Black	8	1564
9	Viper	Small Red	9	1432
10	Eiger	Great Northern	10	1339
11	Lyra	Great Northern	11	1181
12	Aries	Great Northern	12	1016
			Mean:	1795
			LSD:	462
			CV:	21%

*Yield is in pounds per acre obtained by direct harvest, adjusted to 18% moisture. The highest yield in a column is marked by two asterisks(**), any values in a column that are not statistically different are marked by one asterisks (*).

Summary: A trial was established in 2023 to test alternative market classes on irrigated farms in Montcalm County. The 2023 season was marked by plenty of rainfall and very little irrigation needed. White mold disease was severe in this location in 2023 and greatly limited overall dry bean yield. To better understand the natural disease tolerance of these commercial lines no fungicide was applied to the trial. Both Spectre and Zenith statistically outyielded the remaining 10 entries in this high disease pressure location. This supports the findings from other trials, documenting the high level of disease tolerance in these two varieties of black beans (E3465 Michigan Dry Bean performance Trials). We would like to thank the Waldron family for hosting this trial in 2023.

Commercial Dry Bean Production and Quality Trial

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Location: Richville, MI (Planted: June 2, 2023)	**Treated Plot Size:** 6.6' x 25'
Replicated: 12 times	**Row Width:** 20-inch
Design: RCBD	**Population:** 105,000 seeds/A
Nitrogen Rate: 45 lb./A Total	**Total GDD:** 1807
Harvest Date: September 25, 2023	**Total Precipitation:** 13.8"
Soil Type: Clay (3.3% OM, 19.3 CEC)	**Fungicide Applications:** None
PPI *May 23,2023:* Dual II Magnum (1.3 pt) + Prowl H2O (1.6 pt) + Eptam (2 pt)	
POST *June 29, 2023*: Raptor (2 fl oz) + Basagran (20 fl oz) + Outlook (10 fl oz) + COC (1% v/v) + AMS (2.5 Lb.) + Max-in ZMB (16 fl oz)	

Table 1. Variety name, market class, moisture at harvest, yield rank (1-13), dry bean yield, gross income per acre and 2023 canning scores.

Name	Market Class	Moisture at Harvest	Yield Rank	Yield [a]	Gross Income [b]	2023 Canning Scores [c]
Spectre	Black	18.6%	1	32.1**	*$1,287*	2.7 (3.0)
Black Beard	Black	18.2%	2	30.4*	*$1,218*	3.8 (4.1)
HMS Bounty	Navy	19.0%	3	29.5*	*$1,182*	2.5
Kona	Black	18.6%	4	29.4*	*$1,179*	3.6 (3.3)
N19246	Navy	18.9%	5	29.2*	*$1,172*	2.5
Armada	Navy	18.3%	6	29.1*	*$1,164*	2.7
Nimbus	Black	18.3%	7	27.2	*$1,092*	2.8 (2.1)
Black Pearl	Black	18.5%	8	27.1	*$1,086*	3.6 (4.2)
Black Tails	Black	17.7%	9	24.9	*$997*	2.8 (3.3)
B20591	Black	17.4%	10	24.8	*$995*	3.8 (2.8)
Liberty	Navy	18.9%	11	23.8	*$953*	3.3
Zenith	Black	18.0%	12	22.9	*$919*	3.9 (4.4)
AuSable	Navy	17.6%	13	20.8	*$834*	2.6
	Mean:	18.3%	-	27.0	$1083	-
	LSD:	0.6%	-	3.7	-	-

[a]Yield is in hundredweight per acre obtained by direct harvest, adjusted to 18% moisture. The highest yield in a column is marked by two asterisks(**), any values in a column that are not statistically different are marked by one asterisks (*). [b] Gross income per acre was calculated as total yield per acres, adjusted to a standard moisture of 18% and multiplied by $40/ cwt for both classes tested (black and navy). [c]Canning scores are on a scale from 1-5, with 1 being poor and 5 being excellent. Black beans are rated separately for appearance and color. Color is scored also on a scale from 1-5 where 1 is poor and 5 is excellent. Black bean scores are notated as appearance score followed by color Ex: appearance (color).

Summary: A trial was established in 2023 to screen both commercial and precommercial black and navy beans for both production and quality attributes. Thirteen total entries were tested in a highly replicated trial (12 replications per entry). Heavy rainfall damaged plant stands in 2023 however the high level of replication produced a quality data set for both yield and quality parameters. Results show that both black beans and three navy beans yielded within the top statistical group of the trial (Spectre, Black Beard, Bounty, Kona, N19246, & Armada). Within this group if a standard value of $40 per hundred weight was used to calculate gross income per acre all entries produced more than $1,100 per acre in 2023. When analyzing overall processing quality of this commercial entry list black beans have 'above' average (Black Beard) and average (Kona & Spectre) processing varieties in the top yielding group. Top yielding navy beans produced average canning scores in 2023 (Bounty, N19246, Armada).

Dry Bean Varietal Response to Fungicide

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Introduction:
In recent years there has been increasing interest in understanding of how particular 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 thirty-six commercial dry bean varieties (11 black, 15 navy, 1 small red, 2 great northern, 4 pinto, 1 pink, and 1 white kidney) were selected and placed into testing.

Methods:
Dry beans were seeded in four-row plots that measured 6.6′ wide by 25′ long, with 20″ rows on the evening of June 1st 2023 near Sebawaing, MI. Planting population was 105,000 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 **eight 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 (timing "A"). A second application (timing "B") of Propulse (10.3 fl oz) was made 10 d. after "A". 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.

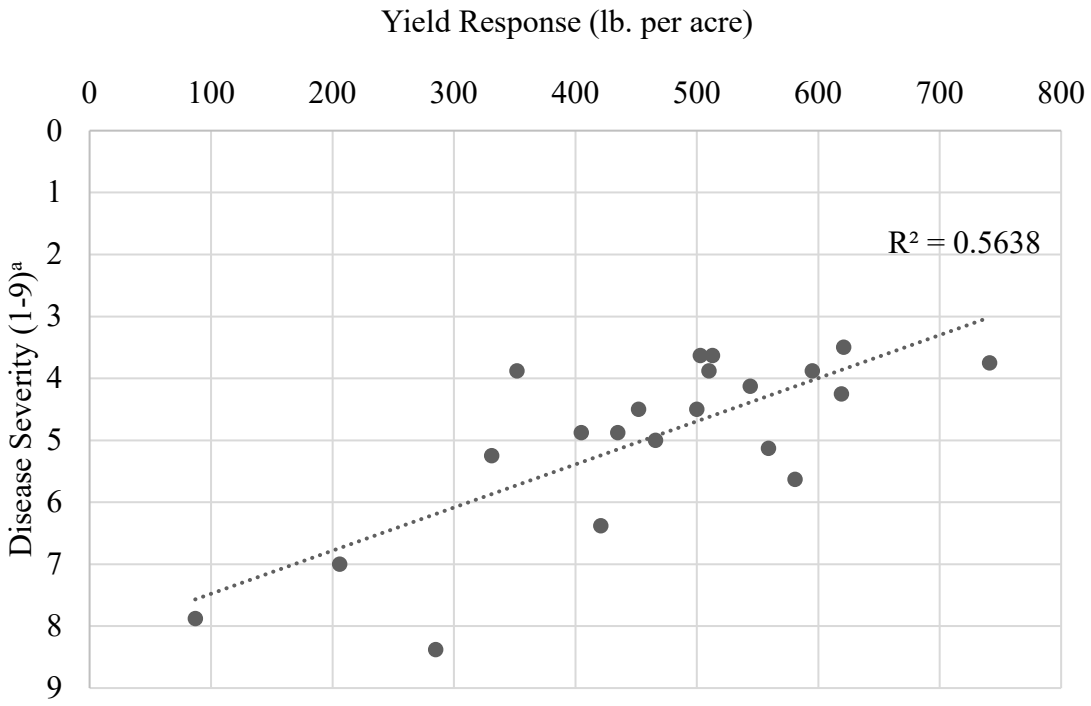
Results:
Trial quality was excellent in 2023. Mid to late season rains resulted in good vegetative growth and pod fill. White mold infection averaged 67% across all plots, sprayed and not sprayed. Both main plot and subplot effects were significant in this testing. **Fungicide:** When averaged across all entries the plots that were sprayed with fungicide yielded 597 lb./A more than the untreated ($P \leq 0.01$) (37.8 cwt vs. 31.9 cwt.). **Variety:** When averaged across fungicide treatments (sprayed and not sprayed) 12 of 36 lines evaluated yielded in the 90th percentile (top 10%) of the trial: Armada (42.8 cwt), Spectre (42.0 cwt), Black Bear (41.6 cwt), Nimbus (41.4 cwt), Medalist (40.8 cwt), Bounty (40.6 cwt), Victory (40.1 cwt), Umbra (39.5 cwt), Eiger (39.1 cwt), Liberty (39.0 cwt), and Bannock (38.7 cwt). 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 a wide range of varietal responses existed when examining treated and untreated yields. In a trial of this size some level of interaction would not be unexpected. However, this interaction becomes more important when we add another evaluation to the data set: disease severity **(*Figure 1.*)**. When plotting yield response (the difference between treated and untreated yield) for each variety against the disease severity score (visual score from 1-9 of how severe disease symptoms were in the untreated) a correlation/positive trend exists between variables. As disease severity scores in the untreated decrease, the yield response increases. In other words, as a general trend, the more tolerant a variety was to white mold the higher the yield response to fungicide was.

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

Variety	Market Class	White Mold Severity (1-9)	Untreated	Propulse (10.3 fl oz)	Yield Response
			Lb. Per Acre[ab]		Lb. Per Acre
Armada	Navy	5.3	4124	4455 *	331
Spectre	Black	3.6	3949	4462*	513
Black Bear	Black	4.1	3351	4973**	1622
BlackBeard	Black	7.0	4055	4261*	206
Nimbus	Black	4.5	3898	4398*	500
HMS Medalist	Navy	4.3	3778	4397*	619
HMS Bounty	Navy	3.9	3770	4365*	595
Victory	Navy	5.1	3737	4296*	559
Umbra	Black	5.0	3716	4182	466
Eiger	GN	6.1	3296	4537*	1241
Liberty	Navy	4.1	3629	4173	544
Bannock	Black	3.6	3573	4163	590
Charm	Navy	3.8	3426	4167	741
ND Pegasus	GN	7.0	3803	3749	-54
Vibrant	SDP	5.1	3257	4022	765
Blizzard	Navy	5.6	3347	3928	581
Argosy	Navy	5.5	3417	3769	352
Valiant	Navy	3.9	3604	3554	-50
Charro	P	4.5	2824	4372*	1343
Mystic	SDP	6.4	3103	3837	734
Black Tails	Black	6.4	3252	3673	421
Black Pearl	Black	3.9	3157	3667	510
Aries	GN	6.9	2863	3934	1071
Eclipse	Black	4.5	3155	3607	452
Viper	SR	7.4	2892	3817	925
Zenith	Black	3.5	2914	3535	621
Nautica	Navy	4.9	2992	3427	435
T9905	Navy	7.0	2609	3654	1045
OAC Seal	Navy	2.9	2792	3397	605
AuSable	Navy	4.9	2873	3278	405
Gleam	SDP	7.3	2625	3464	839
Coral	Pink	3.4	2766	2785	19
Rogue	Navy	7.9	2482	2569	87
ND Twilight	Black	8.4	2274	2559	285
ND Polar	Navy	7.3	1805	2787	982
Beluga	Kidney	1.0	1763	2154	391

[a] Note. The highest yield in the table is marked with two asterisks (**). Any values in the table that are not statistically different from the column's two-asterisk entry are marked with one asterisk. [b] Yield is in pounds per acre obtained by direct harvest, adjusted to 18% moisture.

Figure 1. Severity (1-9) and yield response to fungicide treatment



[a] Severity is scored on a scale from 1-9 where 1 is the lowest severity and 9 is the most severe.

2023 Bayer Irrigated Fungicide Trial

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Locations: Montcalm Research Center	**GPA:** 15
Planting Date: June 9, 2023	**PSI:** 40
Replicated: 4 times	**Nozzle:** XR8002
Design: RCBD	**Timing:** R1 (A) & R3 (B)
Variety: Black Bear Black Beans	**Row width:** 20-inch
Population: 120,000 seeds/A	**Treated Plot Size:** 6.6' x 20'
Harvest Date: October 5, 2023	**Application date**: July 31 (A) & August 10 (B)
PPI June 8 *,2023:* 28-0-0 (20 gal) + Dual II Magnum (1.3 pt) + Prowl H2O (1.6 pt) + Eptam (3 pt)	
POST A *July 10, 2023*: Raptor (4 fl oz) + Basagran (20 fl oz) + Reflex (8 fl oz) + COC (1% v/v) + AMS (2.5 Lb.)	

Table 1. Dry bean fungicide treatments, application timing, disease severity, percent infection and dry bean yield.

#	Treatments	Application Timing	Severity	% infection	Yield [ab]
1	Untreated	-	4.0 a	34	2340
2	Propulse (8 fl oz)	AB	1.8 b	18	2238
3	Propulse (10.3 fl oz)	AB	1.5 b	9	2290
4	Delaro (12 fl oz) Fb. Propulse (8 fl oz)	AB	1.8 b	15	1989
5	Delaro (12 fl oz) + Luna Privilege (2 fl oz) Fb. Propulse (8 fl oz)	AB	3.0 a	19	2224
6	Luna Flex (11 fl oz)	AB	1.8 b	14	2425
7	Luna Flex (13.6 fl oz)	AB	1.5 b	10	2314
8	Luna Flex (11 fl oz) Fb. Propulse (8 fl oz)	AB	1.8 b	14	2261
		Mean:	2.1	16	2260
		LSD:	1.1	17	326
		Cv:	44%	85%	11%

[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 2023. Disease pressure averaged 16% across all treatments, with an average severity of 2.1 (1-9 scale). Treatments were made at two separate timings: (A) R1 and (B) 10 d. after R1. All fungicide applications with the exception of Delaro + Luna Privilege Fb. Propulse significantly reduced disease severity. While not significant the sequential application of Luna Flex (11 fl oz) (Fluopyram + Difenoconazole) produced the highest numerical yield in 2023, producing 2425 lb./A. Luna Flex is not currently labeled for use in dry bean production and was tested for research purposes. The overall lack of disease pressure was surprising given the overall level of rainfall naturally provided in 2023, over 15" between June 15 – September 15, 2023. In addition to natural rainfall additional irrigation of 4.5" was provided during key timepoints of plant development (flowering) to help facilitate white mold disease. However, the timing of natural rainfall facilitated severe root rot disease across the trial that eventually impacted dry bean growth and row closure. Due to root disease, at the key time of flowering the dry bean canopy had not yet closed, resulting in less than average disease and overall dry bean yield. Fungicide trials will be continued in 2024 to continue to build a stronger data set for crop protection decisions. We would like to thank Bayer Crop Science and the Michigan Bean Commission for supporting this research.

2023 Huron County Dry Bean Fungicide Trial

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Locations: Sebawaing, MI	**GPA:** 22
Planting Date: June 1, 2023	**PSI:** 60
Replicated: 4 times	**Nozzle:** XR8002
Design: RCBD	**Timing:** R1 (A)
Variety: Liberty Navy Bean	**Row width:** 20-inch
Population: 105,000 seeds/A	**Treated Plot Size:** 6.6' x 20'
Harvest Date: September 15, 2023	**Application date**: July 19 (A)
PPI *May 31, 2023:* Dual II Magnum (1.3 pt) + Prowl H2O (1.6 pt)	
POST A *June 21, 2023:* Basagran (16 fl oz) + COC (0.5% v/v)	
POST B *June 29, 2023*: Raptor (2 fl oz) + Basagran (16 fl oz) + Outlook (10 fl oz) + COC (1% v/v) + AMS (2.5 lb.)	

Table 1. Dry bean fungicide treatments, application timing, disease severity, percent infection and dry bean yield.

#	Treatments	Application Timing	Severity [ab]	% infection	Yield [c]
1	Untreated	-	3.0	80	3162
2	Endura (8 oz)	A	1.5	63	3263
3	Priaxor (4 fl oz)	A	2.0	45	3295
4	Endura (8 oz) + Priaxor (4 fl oz)	A	1.8	64	3242
5	Endura Pro (20 fl oz)	A	2.3	78	3429
6	Propulse (10.3 fl oz)	A	1.8	59	3097
		Mean:	2.0	65	3248
		LSD:	1.2	32	294
		Cv:	40%	33%	6.0%

[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: A fungicide trial was established on a commercial farm in Huron county in 2023 near Sebawaing, MI. Disease pressure averaged 65% across all treatments. The fungicide programs tested within this trial were all one application programs made at R1. While not significant the application of Endura Pro produced the highest numerical yield in 2023, producing 3429 lb/A when 20 fl oz of Endura Pro was applied one time. Endura Pro is not currently labeled for dry beans and was included for research purposes only. Results indicate the limitations of current fungicide products for the suppression of white mold. With late season rains continuing and high levels of vegetative growth, potential benefits may have been observed if a second fungicide application had been made. Additional challenges include marginal levels of root disease driven by heavy rainfall patterns. Also of note is limited coverage during foliar applications when dense foliage existed as it did in 2023, this becomes an added challenge when testing single application programs (A) such as these. We would like to thank BASF and the Michigan Bean Commission for supporting this research.

2023 Gowan Irrigated Fungicide Trial

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Locations: Montcalm Research Center	**GPA:** 15
Planting Date: June 9, 2023	**PSI:** 40
Replicated: 4 times	**Nozzle:** XR8002
Design: RCBD	**Timing:** R1 (A) & R3 (B)
Variety: Black Bear Black Beans	**Row width:** 20-inch
Population: 120,000 seeds/A	**Treated Plot Size:** 6.6' x 20'
Harvest Date: October 5, 2023	**Application date**: July 31 (A) & August 10 (B)
PPI June 8 *,2023:* 28-0-0 (20 gal) + Dual II Magnum (1.3 pt) + Prowl H2O (1.6 pt) + Eptam (3 pt)	
POST A *July 10, 2023*: Raptor (4 fl oz) + Basagran (20 fl oz) + Reflex (8 fl oz) + COC (1% v/v) + AMS (2.5 Lb.)	

Table 1. Dry bean fungicide treatments, application timing, disease severity, percent infection and dry bean yield.

#	Treatments	Application Timing	Severity	% Infection	Yield [ab]
1	Untreated	-	4.5 a	45 ad	2372 d
2	Domark (6.4 fl oz) + NIS (0.25%)	AB	4.5 a	51 ac	2477 bd
3	Domark (6.4 fl oz) + Badge (32 fl oz)	AB	3.3 ac	41 bd	2395 d
4	Affiance (14 fl oz) + NIS (0.25%)	AB	3.8 ab	50 ad	2647 ac
5	Affiance (14 fl oz) + Badge (32 fl oz)	AB	3.3 ac	62 ad	2686 ab
6	Affiance (14 fl oz) + NIS (0.25%)	A	4.3 a	56 ac	2424 cd
7	Affiance (14 fl oz) + Badge (32 fl oz)	B	3.8 ab	40 ce	2509 ad
8	Endura (8 oz) + NIS (0.25%)	AB	1.5 d	11 f	2756 a
9	Endura (8 oz) + Badge (32 fl oz)	AB	2.0 cd	12 f	2605 ad
10	Propulse (10.3 fl oz) + NIS (0.25%)	AB	2.0 cd	18 ef	2685 ab
11	Propulse (10.3 fl oz) + Badge (32 fl oz)	AB	2.5 bd	15 f	2824 a
14	TopsinM (30 fl oz) + NIS (0.25%)	AB	2.0 cd	28 df	2598 ad
		Mean:	3.2	40	2599
		LSD:	1.5	22	246
		Cv:	38%	46%	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 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 2023. Disease pressure averaged 40% across all treatments and was more uniform and severe in nature than other white mold trials in 2023. There were statistically signifigant differences for disease severity, percent infection and yield results. Eight of the fourteen total treatments statistically grouped in the highest yield percentile, these included the products: Affiance, Endura, Propulse and TopsinM. We would like to thank Gowan and the Michigan Bean Commission for supporting this research in 2024.

2023 Syngenta Irrigated Fungicide Trial

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Locations: Montcalm Research Center	**GPA:** 15
Planting Date: June 9, 2023	**PSI:** 40
Replicated: 4 times	**Nozzle:** XR8002
Design: RCBD	**Timing:** R1 (A) & R3 (B)
Variety: Black Bear Black Beans	**Row width:** 20-inch
Population: 120,000 seeds/A	**Treated Plot Size:** 6.6' x 20'
Harvest Date: October 5, 2023	**Application date**: July 31 (A) & August 10 (B)
PPI June 8 *,2023:* 28-0-0 (20 gal) + Dual II Magnum (1.3 pt) + Prowl H2O (1.6 pt) + Eptam (3 pt)	
POST A *July 10, 2023*: Raptor (4 fl oz) + Basagran (20 fl oz) + Reflex (8 fl oz) + COC (1% v/v) + AMS (2.5 Lb.)	

Table 1. Dry bean fungicide treatments, application timing, disease severity, percent infection and dry bean yield.

#	Treatments	Application Timing	Severity	% infection	Yield [ab]
1	Untreated	-	3.8 a	33	2214
2	Miravis Prime (10.3 fl oz)	AB	1.0 b	11	2369
3	Propulse (10.3 fl oz)	AB	1.5 b	19	2417
4	Omega (8 fl oz)	AB	1.8 b	19	2537
		Mean:	2.0	20	2384
		LSD:	0.8	13	427
		Cv:	33%	47%	13%

[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 2023. Disease pressure averaged 20% across all treatments, with an average severity of 2.0 (1-9 scale). Treatments were made at two separate timings: (A) R1 and (B) 10 d. after R1. All fungicide applications significantly reduced disease severity. While not significant the sequential application of Omega (8 fl oz) (Fluazinam) produced the highest numerical yield in 2023, producing 2537 lb./A. The overall lack of disease pressure was surprising given the above average level of rainfall naturally provided in 2023, over 15" between June 15 – September 15, 2023. In addition to natural rainfall additional irrigation of 4.5" was provided during key timepoints of plant development (flowering) to help facilitate white mold disease. However, the timing of natural rainfall facilitated severe root rot disease across the trial that eventually impacted dry bean growth and row closure. Due to root disease, at the key time of flowering the dry bean canopy had not yet closed, resulting in less than average disease and overall dry bean yield. Fungicide trials will be continued in 2024 to continue to build a stronger data set for crop protection decisions. We would like to thank Syngenta and the Michigan Bean Commission for supporting this research.

Multi-Year Trialing Of Heads Up Seed Treatment

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Locations: Bay, Huron, Sanilac, and Tuscola County	**Population:** 105,000 seeds/A
Years: 2022 and 2023	**Row width:** 20-inch
Replicated: 4 times per location per year	**Treated Plot Size:** 6.6' x 20'
Design: RCBD across locations	**Seed Treater:** Seedburo Batch Lab Seed Treater

Table 1. 2023 Dry bean varieties used, white mold infection and severity in Huron county, yields for individual locations, and combined analysis for yield across locations.

Factor 1: Variety	Factor 2: Seed Treatment	White Mold Infection *(%)*	White Mold Severity (1-9)	Bay *(Lbs./A)*	Huron *(Lbs./A)*	Sanilac *(Lbs./A)*	Tuscola *(Lbs./A)*	1-year avg. *(Lbs./A)*
Spectre	*Cruiser Seed Treatment*	42 a	1.7 a	3232	3694 a	3820 ab	2882	3365 a
	Cruiser Seed Treatment + HeadsUp (0.5oz cwt^{-1})	50 a	1.2 a	3315	3223 bc	4027 a	3189	3471 a
	Cruiser Seed Treatment Fb. HeadsUp (1oz cwt^{-1})	49 a	1.5 a	2864	3736 a	4128 a	2760	3388 a
BlackBeard	*Cruiser Seed Treatment*	93 b	3.2 b	2622	3352 bc	3481 b	2878	3061 b
	Cruiser Seed Treatment + HeadsUp (0.5oz cwt^{-1})	90 b	3.0 b	3116	3497 ab	4109 a	3204	3485 a
	Cruiser Seed Treatment Fb. HeadsUp (1oz cwt^{-1})	89 b	3.5 b	3190	3198 c	3906 ab	3058	3351 a
	MEAN:	69	2.38	3057	3450	3912	2995	3353
	$LSD_{(0.05)}$:	11	0.7	NS	217	355	NS	279
	CV:	13.54%	23.79%	21.96%	5.06%	7.29%	19.04	14.11%

[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.

Cont. on next page

Multi-Year Trialing Of Heads Up Seed Treatment

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Table 2. 2022 Dry bean variety used, white mold infection in Bay and Tuscola, yields for individual locations, and combined analysis for yield across locations.

Factor 1: Variety	Factor 2: Seed Treatment	Bay Co. White Mold Infection (%)	Tuscola Co. White Mold Infection (%)	Bay (Lbs./A)	Huron (Lbs./A)	Sanilac (Lbs./A)	Tuscola (Lbs./A)	1-year avg. (Lbs./A)
BlackBear	*Cruiser Seed Treatment*	13	70	3076	2311	3315	2909	2973
	Cruiser Seed Treatment + HeadsUp (0.5oz cwt^{-1})	33	66	3559*	2509	3189	3211	3117
	Cruiser Seed Treatment Fb. HeadsUp (1oz cwt^{-1})	27	65	3802**	2493	3445	3394	3272
	MEAN:	25	67	3479	2439	3062	3172	3120
	$LSD_{(0.05)}$:	NS	NS	298	NS	NS	NS	NS
	CV:	44.1%	9.8%	6.0%	14.5%	7.6%	12.7%	17.0%

[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: Over the 2022 and 2023 growing seasons Heads Up seed treatment was tested on farm in four locations in Michigan. Heads Up seed treatment is a preplant seed treatment intended to suppress fungal pathogens. Testing methods were similar in both years, testing an untreated control against two different rates/methods of application of the Heads Up seed treatment. It is important to note that the 'untreated' was an industry standard application of Cruiser seed treatment with no Heads Up added. Not to be confused with completely untreated bare seed. This was done because this testing was targeted at testing the effects of the biological seed treatment, and not the effects of Cruiser. The first treatment containing Heads Up was the combination of Cruiser and Heads Up added at a rate of 0.5 oz per cwt of seed applied in a slurry mixture at the same time. The second treatment containing Heads Up both years was a standard treatment of Cruiser that was allowed to dry, then followed by a 1 oz rate per cwt of Heads Up applied overtop of the cruiser. Results of testing indicate that white mold infection rates and levels of severity were not impacted by seed treatment. In 2023 when multiple black bean varieties were tested differences did exist on a variety basis, but not from seed treatment effects. No difference existed for percent infection by seed treatment in 2022. However, when combined for yield individual locations did have significant differences for dry bean yield as a result of seed treatment in 3 of 8 total site years ($\alpha \leq 0.05$). When combined across locations within each year the variety Black Beard significantly yielded more when treated with Heads Up regardless of rate, than when not treated (Table 1.). While some numerical difference exists, neither Spectre (2023) or Black Bear (2022) had statistically different yield results when averaged across all locations tested. While it appears that the positive effects of Heads Up may be variable, there is no evidence to suggest any negative or phytotoxic effects exist when label guidelines are used in the treatment of dry bean seed. We would like to thank Heads Up and the Michigan Bean Commission for supporting this work.

Dry Bean Response to In-Furrow Applications of Propulse

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Location: Richville, MI	**Planting Date:** June 13, 2023
Replicated: 4 times	**Treated Plot Size:** 6.6' x 25'
Design: RCBD	**GPA:** 10
Variety: HMS Bounty	**PSI:** 15
Population: 130,000 seeds/A	**Application Timing:** 'A' at planting
Nitrogen Rate: 45 lb./A	**Nozzle:** XR8002
Harvest Date: September 25, 2023	**Row Width:** 20-inch
Soil Type: Clay (3.3% OM, 19.3 CEC)	**Foliar Fungicide Applications:** None
PPI *May 23,2023:* Dual II Magnum (1.3 pt) + Prowl H2O (1.6 pt) + Eptam (2 pt)	
POST A *June 29, 2023*: Raptor (2 fl oz) + Basagran (20 fl oz) + Outlook (10 fl oz) + COC (1% v/v) + AMS (2.5 Lb.) + Max-in ZMB (16 fl oz)	

Table 1. Treatments, application timing, stand counts, root rot infection (%) and dry bean yield.

#	Treatment	Application Timing	Stand Count/A	Root Rot Infection	Yield *
			105d. after planting	%	
1	Untreated	-	95,432	16.3%	2069
2	Propulse 6 fl. oz./A	A	93,472	16.3%	1631
3	Propulse 8 fl. oz./A	A	88,896	14.3%	1753
4	Propulse 10 fl. oz./A	A	93,472	19.5%	1855
		Mean:	92,818	16.5%	1827
		LSD:	13,626	12.5%	374
		CV:	11.3%	4.9%	15.8%

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

Summary: A trial was established in 2023 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 present but not in high severity. 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 were analyzed evaluations of stand count, root rot infection, nor yield were significantly impacted by fungicide application when compared to the untreated control ($P \leq 0.1$). Additional research is required to better understand the impact Propulse may have on dry bean root diseases.

Validation of Improved Dry Bean Varieties, Maturities, and Integrated Weed Management Systems: PHASE II Managing Production for an Evolving Marketplace

Progress Report-submitted by E.M. Wright

During the 2023 growing season, the MSU Dry Bean Breeding Program conducted field trials both at the SVREC (research station) and on-farm in Huron County. This work relates to objectives 1 and 3 of the SCBG awarded to MBC. At both sites, 60-entry black bean and 36-entry navy bean trials were conducted which allowed for multi-location assessment of agronomic performance and stability across environments representative of the Michigan dry bean growing region. Entries consisted of advanced MSU breeding lines that have previously demonstrated desirable agronomic and seed quality traits, along with appropriate commercial varieties that serve as checks. Data was collected on yield, days to maturity, lodging, plant height, and canning quality based on visual ratings or direct measurement, as appropriate for each trait. Additionally, a similar kidney bean trial was established in Montcalm County to collect data for the same traits for MSU kidney bean breeding lines.

UAS flights with an RGB camera were conducted at biologically significant developmental stages throughout the growing season to collect image data at all field locations. In general, flights commenced at the flowering stage (R1) and continued on a 7–10-day interval to allow calculation of vegetation indices throughout the season, with flights intensifying to twice weekly during the maturation and senescence stage to allow more precise estimation of maturity date for each plot. Orthomosaics were generated and a shapefile overlaid to associate geotagged pixel level data with individual plots at each timepoint. Analysis of individual plot data was performed according to the methods developed in our lab by Volpato et al (in press). Briefly, estimation of maturity relies on modeling decay of canopy greenness over time, while estimation of plant height is calculated from the difference in elevation from the top of the plant canopy (measured via Digital Surface Model) to the soil surface. Data analysis from the 2023 field season is ongoing, but this method was previously shown to reliably estimate plant maturity within 2 days of ground truth date measured by visual ratings (2021-22 seasons). Additionally, estimates of plant height were calculated as described in Volpato et al. At the SVREC site, similar UAS flights were conducted on the F4 breeding nursery and maturity and plant height estimates were based on a family mean basis, representing the first application of this emerging high throughput phenotyping technique to our early-generation breeding populations.

Significant impacts from this project include:

1) Selection of navy and black bean breeding lines with high yield potential, uniform dry down, appropriate maturity across locations, and acceptable canning quality that will be advanced to 2024 trials.
2) Optimization and publication of high throughput phenotyping methods to estimate maturity and plant height.

3) Release of mid-season maturity AuSable navy bean, which matures in 95 days on average (7-10 days earlier than full-season varieties in the marketplace), possesses resistance to anthracnose race 73, and dries down uniformly and efficiently without the use of dessicants.
4) Release of Black Pearl black bean with high yield potential, 98 day maturity, acceptable dry down without the use of dessicants, anthracnose resistance (race 73), and exceptional color retention when canned which has been a deficiency of several recent varieties in the marketplace.
5) Proposed release of B20536 breeding line which possesses high yield potential, acceptable canning quality, and more upright plant architecture to reduce white mold infection.

Publications:

Gomez, F.E., Kelly, J.D., Wright, E.M., Awale, H.E. and Bales, S. 2024. Registration of AuSable navy bean. Journal of Plant Registrations (submitted).

Gomez, F.E., Kelly, J.D., Wright, E.M., Awale, H.E. and Bales, S. 2024. Registration of Black Pearl black bean. Journal of Plant Registrations (submitted).

Volpato, L., Wright, E.M., and Gomez, F.E. 2023. Digital phenotyping in plant breeding: Evaluating relative maturity, stand count, and plant height in dry beans (*Phaseolus vulgaris* L.) via RGB drone-based imagery and deep learning approaches. Research Square (preprint). https://doi.org/10.21203/rs.3.rs-3160633/v1

Volpato, L., Wright, E.M., and Gomez, F.E. 2024. Drone-based digital phenotyping to evaluate relative maturity, stand count, and plant height in dry beans (Phaseolus vulgaris L.). Plant Phenomics (submitted).

Expt. 2301: Standard Navy Bean Yield Trial

This 36-entry trial included standard commercial navy bean varieties, and advanced lines from the MSU breeding program. Yields ranged from 18.8 to 32.0 cwt/acre with a mean of 25.1 cwt/acre. Variability in this trial was well controlled (CV= 9.6%) and the LSD needed for significance was 2.8 cwt/acre. Five breeding lines significantly outyielded the test mean, and overall navy yields were nearly equivalent to those of black beans. Three of these lines were newer N22617, N22622, and N22623 lines that also ranked at the top of the preliminary yield trial in 2022 and continued to show potential in 2023. The persistent yield performance of N19277 and N18105 which have ranked within the top ten entries consistently over the past five years despite contrasting seasons is noteworthy. N22616 ranked 6th in this trial, but also performed impressively in the Michigan Dry Bean Performance trials where it was the highest yielding MSU navy entry with a 4 location mean of 31.5cwt and appears to offer exceptional yield and overall agronomic characteristics. Given continued interest in enhancing sustainability and the current conversations regarding potential need for reduced desiccant use in the future to satisfy consumer perception of environmental impacts of bean production, selection for efficient dry down and uniform maturity continues to be a major selection target. Commercial checks in this trial all ranked at or below the trial mean. Newer private varieties Liberty and HMS Bounty produced lower yields than expected due to complete susceptibility to CBB infection that reduced yield. 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. The older MSU variety Alpena has proved a more stable check for these conditions, and in 2023 it performed equivalent to new early mid-season variety AuSable which matured 1 week earlier than any other entries. Canning tests will be conducted on all entries before being considered for advance to future trials.

Expt. 2302: Standard Black Bean Yield Trial

This 60-entry trial included standard commercial black bean varieties and advanced breeding lines. Yields ranged from 21.2 to 33.3 cwt/acre with a test mean of 27.7 cwt/acre. Variability was moderate in this test, (CV=11.0%) and the LSD was 3.6 cwt/acre. Four entries significantly out yielded the test mean which included B22062, B22042, and B22054. B20536, which is in the process of commercialization as the variety 'Kona', was also among this group with a yield of 31.9cwt, marking the third season it has ranked at the top of this trial. B22041 (30.8cwt) ranked 5th in this trial but showed excellent yield and agronomic potential in the multi-location Performance Trials where it averaged 37.7cwt across four locations. Spectre (30.7cwt), Adams (28.8cwt), Zenith (28.4cwt), and new release Black Pearl (27.9cwt) were the varieties ranking above the trial mean. Zenith continues to show stable and competitive yield potential in recent years. Given recent concerns about canning quality in the industry, this variety and the newer Black Pearl should not be overlooked by growers seeking black beans with exceptional color retention (in addition to anthracnose resistance) for the canning market. In contrast, Nimbus (25.7 cwt) ranked below the mean due largely to disease susceptibility, while Zorro (24.2cwt) was the lowest yielding and oldest variety in the trial, underscoring impressive yield gains made through intensive black bean breeding over the past 20+ years. All entries will be canned to evaluate color retention and quality to inform decisions on advancement to 2024 testing.

EXPERIMENT 2301 STANDARD NAVY BEAN YIELD TRIAL								PLANTED: 6/6/23	
NAME	PEDIGREE	ENTRY	YIELD CWT /ACRE	100 SEED WT. (g)	DAYS TO FLOWER	DAYS TO MATURITY	LODGING (1-5)	HEIGHT (cm)	DES. SCORE
N19277	N14229/N14218	28	32.0	20.2	52.5	110.0	1.5	39.0	5.0
N22617	N19216/N17505	27	28.2	19.6	51.0	109.0	1.5	40.8	5.5
N18105	N13131/N14201	5	28.2	19.1	50.0	109.0	2.0	50.8	5.5
N22622	N19216/B18224	20	28.1	22.6	52.0	109.0	1.0	47.0	5.0
N22623	N19241/N18103	24	27.9	23.9	50.5	110.0	1.0	39.8	4.5
N22616	N19216/N17505	19	27.6	20.9	51.0	108.5	1.5	46.0	6.5
N22005	N15306/B17023	36	27.5	20.6	52.5	110.0	2.0	45.8	6.0
N21513	N15306/N16405	15	27.4	19.6	52.0	110.0	2.0	41.8	4.5
N22632	N18112/B10244	35	27.2	21.8	53.0	110.0	1.0	37.8	4.0
N21511	N15306/N15337	13	27.1	21.1	53.0	110.5	2.0	39.3	5.0
N22618	N19216/N17505	23	26.3	20.0	51.5	108.0	1.0	37.8	5.5
N20395	B16504/N17504	9	26.0	20.5	51.0	105.0	1.0	39.3	5.0
N22602	N17505/N18122	29	26.0	23.1	53.0	109.0	1.0	42.0	5.0
N21523	N17504/B15430	8	25.6	20.6	52.0	110.0	1.5	42.3	4.5
I22001	**LIBERTY**	7	25.5	22.0	50.5	112.5	2.0	43.0	4.0
N22630	N19253/B19309	21	25.4	18.6	54.0	111.0	1.5	42.0	5.0
N21522	N17504/B15430	6	25.3	19.3	52.5	110.5	1.0	46.5	4.5
N21520	N17504/N14229	10	25.3	19.5	52.0	107.0	1.5	38.0	4.0
N21532	B16504/B11519	2	25.2	20.7	51.5	111.0	2.0	45.8	3.5
N22610	N18122/N19253	31	25.2	21.2	54.0	111.5	2.0	45.8	4.0
N21510	N15306/N14229	1	24.9	19.5	50.0	108.5	1.0	46.5	5.5
N22609	N18122/N19253	32	24.9	23.8	54.0	111.0	2.0	43.3	3.5
N20401	B16505/N17504	4	24.6	19.5	51.0	108.5	1.5	39.8	4.5
N22605	N17505/B18224	22	24.3	21.1	53.0	111.0	2.0	44.0	4.5
N21503	N14218/N17504	11	23.9	17.2	52.0	110.5	1.5	38.8	4.0
N19246	N15331/N16405	14	23.6	21.4	50.5	109.0	1.0	40.0	4.5
N22603	N17505/N18122	26	23.4	22.4	53.0	110.5	1.5	45.3	4.0
N11283	MEDALIST/N08003, **ALPENA**	16	23.2	18.3	49.5	108.0	1.5	44.8	4.5
N18103	N13120/PR00806-81, **AUSABLE**	18	22.3	24.5	49.5	101.5	1.5	40.3	4.5
N22636	B16501/N15306	30	22.3	21.5	52.0	108.0	1.5	36.0	4.0
N22629	N19253/B18504R	25	22.2	18.7	53.0	111.0	1.5	43.3	4.0
N21526	N17506/N14229	3	21.9	18.7	51.0	109.0	1.5	40.5	4.5
I21920	**HMS BOUNTY**	17	21.7	19.9	49.5	113.0	2.0	45.3	4.0
N20317	N14218/N17504	12	21.7	19.3	52.0	105.0	1.5	38.5	4.5
N22613	N18130/N17505	33	21.4	21.3	54.0	108.0	1.0	42.0	5.0
N22614	N18130/N17505	34	18.8	21.3	51.5	108.0	1.0	37.0	4.0
MEAN (36)			25.1	20.6	51.8	109.2	1.5	42.1	4.6
LSD (0.05)			2.8	0.7	1.7	1.8	0.8	6.5	1.1
CV (%)			9.6	3.0	1.9	1.0	29.7	13.2	14.0

EXPERIMENT 2302 STANDARD BLACK BEAN YIELD TRIAL								PLANTED: 6/6/23	
NAME	PEDIGREE	ENTRY	YIELD CWT /ACRE	100 SEED WT. (g)	DAYS TO FLOWER	DAYS TO MATURITY	LODGING (1-5)	HEIGHT (cm)	DES. SCORE
B22062	B18231/B18233	51	33.3	25.6	54.0	110.0	1.0	41.4	4.9
B22042	B17536/B18504	46	32.5	23.2	51.5	108.5	1.0	42.3	5.5
B20536	B15430/B16504, **KONA**	5	31.9	24.0	52.5	109.5	1.5	46.3	5.5
B22054	B18210/B18232	57	31.3	25.9	54.5	109.5	1.0	47.8	5.5
B22041	B17536/B18504	45	30.8	23.6	51.5	109.5	1.5	42.8	6.5
I19702	BL14497, **BLACK SPECTRE**	18	30.7	23.4	52.5	112.5	2.0	46.5	4.0
B22043	B17536/B18504	49	30.5	23.8	53.0	110.0	2.0	36.8	4.5
B20547	B16501/B16504	6	30.4	22.9	51.0	109.0	1.5	43.8	4.5
B20599	B16506/B15430	19	30.2	23.1	51.5	109.0	1.5	44.3	4.5
B22843	B18232/B16501	26	29.8	24.7	51.0	107.0	1.0	43.5	5.5
B22044	B17536/B18504	56	29.7	24.3	53.5	111.0	1.5	43.0	4.5
B22854	B19309/B18222	23	29.5	25.1	52.5	106.5	1.0	42.8	6.0
B22827	B17897/B18204	27	29.4	26.1	52.0	108.0	1.0	47.5	5.5
B21711	B16501/B15430	12	29.1	23.0	52.5	106.0	1.0	42.3	5.0
B22874	B18231/B18233	24	29.1	24.4	52.0	106.5	1.5	44.5	5.5
B22812	N15306/B10244	36	29.0	21.2	51.0	107.0	1.0	38.0	5.0
B18504	Zenith//Alpena*/B09197, **ADAMS**	10	28.8	23.6	52.0	111.0	2.0	44.3	4.5
B22817	B16501/B18224	21	28.8	23.9	51.0	108.5	2.0	39.5	4.5
B21715	B16501/B16504	4	28.7	21.8	52.5	109.0	2.0	41.0	5.0
B22875	B18231/B18233	28	28.7	23.7	53.0	107.5	1.0	43.8	5.5
B19309	B15414/B16504	13	28.6	21.9	54.0	108.5	1.0	42.8	4.5
B22003	N15306/B10244	47	28.4	21.8	53.0	110.0	1.0	40.8	4.0
B10244	B04644/ZORRO, **ZENITH**	15	28.4	23.0	49.0	110.0	1.5	42.0	4.5
B22033	B15434/B18204	48	28.3	23.5	51.5	110.0	1.0	44.3	5.5
B21710	B16501/B15430	1	28.3	20.7	53.0	106.5	1.0	39.8	5.0
B22805	N18122/B18224	33	28.1	23.2	51.0	106.5	1.0	45.5	5.0
B22852	B19302/B18232	40	28.0	22.4	50.5	108.0	1.0	42.5	6.0
B22035	B15434/B18504	52	28.0	22.5	51.5	109.5	1.0	41.5	6.0
B19344	B16506/B16507, **BLACK PEARL**	8	27.9	23.3	50.0	109.5	1.5	43.5	4.5
B20602	B16506/B16504	17	27.8	27.1	49.5	105.5	1.0	41.8	5.0

EXPERIMENT 2302 STANDARD BLACK BEAN YIELD TRIAL								PLANTED: 6/6/23	
NAME	PEDIGREE	ENTRY	YIELD CWT /ACRE	100 SEED WT. (g)	DAYS TO FLOWER	DAYS TO MATURITY	LODGING (1-5)	HEIGHT (cm)	DES. SCORE
B20617	B17106/N14218	43	27.5	21.4	52.0	105.5	1.0	42.5	4.0
B22826	B17897/B18204	29	27.3	24.1	53.5	105.0	1.0	36.3	4.0
B22039	B15434/B18504	58	27.2	24.0	50.0	110.0	1.5	44.8	5.5
B22855	B15447/B18504	22	27.2	22.9	51.5	109.0	1.5	46.0	4.5
B20549	B16501/B16504	3	27.1	24.5	50.5	102.0	1.0	40.0	4.5
B22040	B15434/B18504	54	27.0	22.4	52.5	110.0	1.0	47.0	4.5
B22037	B15434/B18504	55	27.0	22.6	52.5	109.5	1.0	41.0	5.0
B20639	B17730/B15430	7	27.0	21.6	53.5	107.5	1.0	41.3	5.5
B22837	B18204/B18232	30	26.8	22.6	51.0	104.0	1.5	38.8	4.0
B22864	B15434/B18204	59	26.7	25.7	51.5	111.0	1.5	37.3	4.0
B22844	B18232/B17207	25	26.7	24.6	52.0	105.0	1.0	41.0	5.5
B22836	B18204/B18224	35	26.6	25.1	51.5	110.0	1.5	42.5	4.5
B22047	B18201/B10244	50	26.3	23.5	51.0	106.5	1.0	40.0	4.5
B22031	B15434/B18204	60	26.3	25.5	51.5	108.5	1.5	45.3	5.0
B21713	B16501/B16504	2	26.3	23.3	52.0	109.0	1.0	41.5	5.0
B22835	B17922/B19309	31	26.1	21.6	53.5	107.5	1.0	36.5	4.0
B22045	B17536/B18504	53	26.1	21.8	50.5	111.0	1.5	45.5	5.0
B22846	B18232/B18204	32	26.0	25.3	52.5	107.5	1.0	41.3	4.5
B21714	B16501/B16504	16	26.0	22.1	51.5	108.5	1.0	42.8	4.0
B20591	B16505/B16504	11	25.9	23.0	52.0	109.0	1.5	43.8	4.5
B22802	N17505/B18224	41	25.9	23.8	52.0	111.0	2.0	47.0	4.0
B22823	B17207/B18504R	37	25.9	21.9	52.5	107.5	1.0	41.5	5.0
I21901	BL14500, **NIMBUS**	14	25.7	24.5	52.5	112.5	2.0	46.3	3.5
B21720	B16505/B16504	9	25.5	21.1	51.0	110.0	1.5	39.0	4.5
B22867	B17536/B18504	44	24.8	23.6	51.5	107.5	1.0	36.8	4.5
B22868	B17922/B10244	38	24.6	20.3	51.5	107.5	1.0	38.5	4.0
B22870	B18201/B10244	34	24.4	22.8	52.0	107.0	1.0	37.5	4.5
B04554	B00103*/X00822, **ZORRO**	20	24.2	23.3	51.0	110.0	2.0	39.5	4.0
B22816	N18128/B18231	39	23.1	21.8	52.0	108.0	1.0	39.3	4.5
B22841	B18224/B17897	42	21.2	21.9	52.0	110.0	2.0	38.0	4.0
MEAN (60)			27.7	23.3	51.9	108.4	1.3	42.1	4.8
LSD (0.05)			3.6	1.0	2.0	2.6	0.6	5.3	1.0
CV (%)			11.0	3.7	2.3	1.4	29.3	10.8	13.0

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan State University AgBioResearch

Overlapping residuals for waterhemp control in dry edible beans

Christy Sprague and Brian Stiles, Michigan State University

Location:	Shiawassee County	**Tillage:**	Conventional
Replicated:	4 times	**Row width:**	30-inch
Planting Date:	June 21, 2023	**PRE application date:**	June 22, 2023
Variety:	'Adams' black beans	**EPOS application:**	21 d after planting
		POST application:	36 d after planting

Table 1. Dry bean injury and yield and waterhemp control from various treatments comparing applications timings of the Group 15 residual herbicides, Outlook and Dual Magnum.

		Dry bean			Waterhemp control
		Injury			
Herbicide treatments		**28 DAP[a]**	**60 DAP[b]**	**Yield**	**100 DAP**
PREs	**EPOS/POST[c]**	— % —	— % —	cwt/A	— % —
None	Varisto (21 fl oz) (EPOS)	6	0	26.7	5
None	Reflex (1 pt) (EPOS)	6	1	27.8	96
None	Reflex (1 pt) + Varisto (21 fl oz) (EPOS)	14	1	27.3	100
None	Outlook (21 fl oz) + Reflex (1 pt) (EPOS)	23	4	29.0	100
None	Dual II Magnum (2 pt) + Reflex (1 pt) (EPOS)	25	3	31.5	100
Outlook (21 fl oz)	Varisto (21 fl oz) (POST)	24	16	30.9	94
Dual Magnum (2 pt)	Varisto (21 fl oz) (POST)	28	24	31.2	96
Outlook (11 fl oz)	Outlook (10 fl oz) + Varisto (21 fl oz) (POST)	6	4	29.9	98
Dual Magnum (1 pt)	Dual Magnum (1 pt) + Varisto (21 fl oz) (POST)	5	5	33.5	91
Outlook (11 fl oz)	Outlook (10 fl oz) + Reflex (1 pt) + Varisto (21 fl oz) (POST)	4	4	27.7	100
Dual Magnum (1 pt)	Dual Magnum (1 pt) + Reflex (1 pt) + Varisto (21 fl oz) (POST)	6	5	31.0	100
	Untreated	0	0	20.3	0
$LSD_{0.05}$[d]		*7.1*	*3.5*	*4.72*	*8.1*

[a] The 28 DAP evaluation was 7 d after the EPOS application.
[b] The 60 DAP evaluation was 25 d after the EPOS application and 14 d after the POST application.
[c] All treatments were applied with crop oil concentrate (COC) (1% v/v) + AMS (2.5 lb).
[d] 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. **Outlook** and **Dual Magnum/Dual II Magnum** are **residual** (Group 15) herbicides labeled postemergence **(POST)** applications after dry beans reach the 1st trifoliate stage (V1). The total maximum use rates per season for dry beans are 21 fl oz/A for Outlook and 2 pt/A for Dual Magnum. There is a 70 d preharvest interval (PHI) for Outlook and a 50 d PHI for Dual Magnum. In 2023, we conducted a field study to examine various treatments and treatment timings for control of glyphosate- and ALS-resistant waterhemp in dry beans. We compared maximum-use rate applications (PRE or EPOS) and split-applications (PRE followed by POST) of the Group 15 herbicides Outlook and Dual Magnum with and without Reflex. Reflex was included to control emerged waterhemp. This is effective on waterhemp populations that are not yet resistant to the Group 14 herbicides, as in this study. However, in certain fields in the state where Group 14 resistance is present the POST application of Reflex would not be effective.

This year immediately after planting there was 1.95-inches of rainfall within two weeks of application. This rainfall provided good incorporation of the PRE herbicide applications and where the full-maximum rate of Outlook or Dual Magnum was applied PRE significant dry bean injury (24-28%) occurred. Injury from the PRE full-rate applications consisted of stunting, reduced leaf area, and leaf crinkling. This injury resulted in a delay in dry bean maturity. When these herbicides were applied at a ½-rate for a split application dry bean injury was not significant (<10%). The full rate EPOS applications of these herbicides when applied with Reflex also caused substantial injury, 7 d after treatment. However, by 25 d after treatment dry bean outgrew the injury from the EPOS treatments, but dry bean injury from the maximum full-rate applied PRE was still relatively high. Splitting the application rates of Outlook or Dual Magnum between the PRE and POST application with Varisto or Reflex + Varisto resulted in relatively low dry bean injury (minor leaf yellowing or burn). Overall, dry bean injury from the herbicide treatments had little effect on yield when compared with any of the standard treatments of Varisto, Reflex or Varisto + Reflex. Waterhemp control at the end of the season was excellent with all treatments that contained Reflex or a split-overlapping application of Outlook or Dual Magnum. 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 or Dual Magnum, PRE followed by EPOS/POST, especially if Reflex is in the POST application.

Recommendations for waterhemp control in dry bean:

- Start out with a soil-applied application of Outlook or Dual Magnum.
    - Use the appropriate rate for the soil type.
    - Preplant incorporated applications will improve crop safety.
- Split-applications (overlapping) of Outlook or Dual Magnum will provide extended waterhemp control. Apply the POST application prior to new waterhemp emergence. Tank-mixing these applications with Reflex will control emerged waterhemp if they are not resistant to the Group 14 herbicides.
    - Outlook 11 fl oz/A (PPI) followed by 10 fl oz/A (POST)
    - Dual Magnum 1 pt/A (PPI/PRE) followed by 1 pt/A (POST)

Dry bean desiccation using Defol 5

Christy Sprague and Brian Stiles, Michigan State University

Location:	Tuscola County	**Tillage:**	Conventional
Planting Date:	June 14, 2023	**Row width:**	30-inch
Replicated:	4 times	**Population:**	109,000 seeds/A
Varieties:	'Zenith' black beans	**Desiccation date:**	Sept. 13, 2023

Table 1. Preharvest treatments on 'Zenith' black bean leaf, pod, and stem desiccation (%) 3, 7, 10 days after treatment (DAT) and dry bean yield.

		7 DAT				Yield
Treatments[a]	**3 DAT**	**leaf**	**pod**	**stem**	**10 DAT**	(cwt/A)
Sharpen (1 fl oz) + Hot MES + AMS	72 d[b]	95 b	99 ab	98 a	100 a	25.9
Sharpen (2 fl oz) + Hot MES + AMS	78 cd	100 a	100 a	100 a	100 a	26.8
Defol 5 (2.4 qt) + Hot MES	80 bc	97 ab	93 c	98 a	100 a	28.2
Defol 5 (4.8 qt) + Hot MES	88 a	99 a	97 b	99 a	100 a	24.6
Defol 5 (2.4 qt) + Sharpen (1 fl oz) + Hot MES + AMS	87 a	100 a	100 a	100 a	100 a	25.3
Gramoxone 3SL (21 fl oz) + NIS	83 ab	97 ab	97 b	97 a	100 a	27.4
Defol 5 (2.4 qt) + Gramoxone 3 SL (21 fl oz) + Hot MES	87 a	98 a	99 ab	99 a	100 a	25.2
Sharpen (1 fl oz) + Gramoxone 3 SL (21 fl oz) + Hot MES + AMS	83 ab	99 a	100 a	100 a	100 a	24.8
Untreated	51 e	67 c	83 d	84 b	92 b	27.0

[a] Hot MES is a surfactant + MSO blend applied at 16 fl oz/A. The liquid AMS product was applied at 2.5% v/v.
[b] Means within a column with different letters are significantly different from each other.

Summary: The objective of this research was to examine Defol 5 as a dry bean desiccant and compare it with current standard desiccation treatments. Defol 5 (42.3% sodium chlorate) is a product that has been used for seed corn defoliation for several years. Defol 5 has a dry bean label with a 0 d preharvest interval but has had very little work on its effectiveness as a dry bean desiccant. All preharvest treatments were applied when dry beans pods were at 70% yellow at 10 gallons per acre to insure good uniform spray coverage. At 3 DAT, the highest rate of Defol 5 provided the greatest dry bean desiccation and was similar to treatments that contained Gramoxone. By 7 DAT, all desiccation treatments provided 95% or greater desiccation of dry bean leaves, pods, and stems. While dry bean maturity for the no desiccation control treatment was 67, 83, and 84% for leaves, pods, and stems, respectively. Dry bean yield for all treatments was similar. From this research there are some promising results for Defol 5 as a dry bean desiccant, however additional studies should be conducted under less favorable conditions to evaluate its consistency. Additionally, it will be important to examine how effective Defol 5 is at desiccating different weed species that may be present at dry bean harvest.

Chapter 5 – Weed Control in Dry Edible Beans

This chapter is intended to provide herbicide information for weed control in dry edible beans. To effectively manage weeds, a combination of cultural, chemical, and sometimes even mechanical weed control practices are implemented. Below is a listing of recommendations and considerations that should be followed for effective weed management in dry edible beans.

Recommendations and Considerations:

1. Cultural practices.

A competitive crop can help with weed management in dry beans. Planting dry beans in narrow rows (20-inches or less) improves early-season canopy closure that can help suppress late-emerging weeds.

2. Herbicide-resistant weeds.

Group 2 (ALS) resistant weeds, especially common ragweed and waterhemp, are some of the biggest weed control challenges in dry bean production. Resistance to this group of herbicides and the potential new resistance issues to the **Group 14** (PPO-inhibiting) herbicides can eliminate normally effective herbicides for weed control. It is important to know the specific herbicide site of action (SOA) group(s) that a weed is resistant to in order to select the most effective herbicide for control.

3. Weed control before or at planting.

Effective weed control in dry beans requires that all weeds be controlled prior to dry bean emergence. This is generally accomplished with tillage prior to dry bean planting. However, if weed growth is excessive growers may want to control existing vegetation with a burndown application prior to tillage or planting. Currently, glyphosate, Gramoxone, and Sequence (**Table 5B**) are the only herbicides registered for this use prior to planting dry beans.

4. Soil-applied herbicides.

The use of soil-applied residual herbicides prior to or at dry bean planting is the foundation to an overall season-long weed control program. Soil-applied herbicides can be applied PP, PPI, or PRE. Eptam, trifluralin, and Sonalan need to be incorporated to be effective. Additionally, incorporation can also improve dry bean tolerance to certain herbicides. **Table 5A** provides the effectiveness of soil-applied herbicides and **Table 5B** provides important information on each soil-applied herbicide.

5. Postemergence herbicides.

One postemergence herbicide application will not consistently provide season-long weed control in dry beans. Therefore, it is important that postemergence herbicide applications follow a good soil-applied herbicide program. In some cases, a grower may decide to make two postemergence applications instead. However, all postemergence applications need to be made prior to weeds reaching 2-inches tall. **Table 5A** provides the effectiveness of postemergence herbicides, and **Table 5B** contains important information on each postemergence herbicide. For extended or late-season weed control of grasses and waterhemp, Dual Magnum or Outlook can be tank-mixed and applied with a postemergence herbicide. Consult **Table 5B** for more information.

6. Preharvest herbicide applications.

Preharvest herbicides or “harvest aids” are used to desiccate or dry down “green” plant tissue that can hinder dry bean harvest. The main purpose of these herbicide applications is to desiccate weeds; however, many growers use these herbicide applications to speed up and/or even out the maturing process of dry beans. **Table 5C** provides information on the effectiveness, benefits, and limitations of these applications.

7. Rotation restrictions.

Prior to herbicide use it is always important to determine if the herbicide application that you make this year may affect your crop rotation plan for the following years. **Table 12** provides a complete listing of crop rotation restrictions for all dry bean herbicides.

Abbreviations for this chapter:

Herbicide Formulations: Table 14
Herbicide Sites of Action: Pages 14-15

Application Timings:

PP = preplant
PPI = preplant incorporated
PRE = preemergence
POST = postemergence

Units of Measure:

fl oz = fluid ounces
lb = pounds
oz = ounces
pt = pints
% v/v = % volume/volume

Additives:

AMS = ammonium sulfate
COC = crop oil concentrate
MSO = methylated seed oil
NIS = non-ionic surfactant

Dry Bean Traits:

N = no specific trait required

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

			Annual Broadleaves											Annual Grasses								Perennials			
Preplant Incorporated	**Site of Action**	Dry Bean Tolerance**	Cocklebur	Horseweed (marestail)[a]	Jimsonweed	Lambsquarters	Nightshade (E. black)[b]	Pigweed	Ragweed (Common)	Smartweed	Velvetleaf	Waterhemp[c]	Wild mustard	Barnyardgrass	Crabgrass	Giant foxtail	Green foxtail	Yellow foxtail	Fall panicum	Witchgrass	Sandbur	Bindweed (Field & Hedge)	Canada thistle	Quackgrass	Yellow nutsedge
Dual Magnum, others	15	2	N	P	N	P	F	**G**	P	P	N	**G**	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	P	N	N	N	**G**
Eptam	15	2	P	N	P	**G**	F	F	F	F	F	P	F	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**G**	N	N	F	F
Outlook	15	3	N	N	N	P	**G**	**G**	P	P	N	**G**	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	P	N	N	N	F
Prowl H_2O/Prowl	3	1	N	P	N	**G**	P	F	P	P	F	F	P	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**G**	N	N	N	N
Pursuit	2	3	F	N	F	P	**E**	**E**	P	F	F	N	**G**	P	P	F	F	F	P	P	P	N	N	N	F
Sonalan	3	1	N	P	N	**G**	F	**G**	P	P	N	F	P	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**G**	N	N	N	N
Trifluralin	3	1	N	P	N	**G**	N	**G**	N	P	N	F	P	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**G**	N	N	N	N
Preemergence																									
Dual Magnum, others	15	2	N	P	N	P	F	**G**	P	P	N	**G**	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	P	N	N	N	F
Outlook[d]	15	4	N	N	N	P	**G**	**G**	P	P	N	**G**	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	P	N	N	N	F
Permit/Sandea	2	3	F	N	F	F	P	**E**	**G**	P	**G**	N	**E**	N	N	N	N	N	N	N	N	N	N	N	F
Pursuit	2	3	P	N	P	P	**E**	**E**	P	F	P	N	**G**	P	P	F	F	F	P	P	P	N	P	N	F
Reflex	14	2	P	N	P	**G**	**E**	**E**	**G**	**G**	P	**G**	**E**	N	N	N	N	N	N	N	N	N	N	N	N
Sequence	9/15	2	N	P	N	P	F	**G**	P	P	N	**G**	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	P	N	N	N	F
Postemergence																									
Assure II	1	1	N	N	N	N	N	N	N	N	N	N	N	**G**	**G**	**E**	**E**	F	**E**	**E**	**E**	N	N	**E**	N
Basagran	6	2	**E**	F	**G**	F	P	P	F	**E**	**G**	N	**E**	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	N	N	**E**	**G**	**E**	**E**	**E**	**E**	**E**	**E**	N	N	**G**	N
Permit	2	3	**E**	N	**G**	N	P	**E**	**G**	F	**G**	N	**E**	N	N	N	N	N	N	N	N	P	P	N	**E**
Poast	1	1	N	N	N	N	N	N	N	N	N	N	N	**E**	**G**	**E**	**E**	**E**	**E**	**E**	**E**	N	N	F	N
Pursuit	2	3	F	N	P	P	**E**	**E**	P	F	F	N	**E**	P	P	F	P	P	P	P	P	N	P	N	F
Pursuit + Basagran	2/6	2	**E**	P	**G**	F	**E**	**E**	F	**G**	**G**	N	**E**	P	P	F	P	P	P	P	P	N	**G**	N	**G**
Raptor	2	3	F	N	F	F	**E**	**E**	P	F	**G**	N	**E**	F	P	F	P	P	P	P	P	N	P	N	P
Raptor + Basagran 5L (6.4 fl oz)	2/6	2	**G**	P	F	F/**G**	**E**	**E**	F	**G**	**G**	N	**E**	F	P	F	P	P	P	P	P	N	F	N	F
Raptor + Basagran 5L (12.8 fl oz)[e]	2/6	2	**E**	F	**G**	**G**	**E**	**E**	F	**E**	**G**	N	**E**	P	P	F	P	P	P	P	P	N	**G**	N	F
Reflex	14	2	P	P	F	P	**G**	**G**	**E**	P	P	**G**	**E**	N	N	N	N	N	N	N	N	N	N	N	N
Reflex + Basagran	14/6	2	**E**	F	**G**	F	**G**	**G**	**E**	**E**	**G**	**G**	**E**	N	N	N	N	N	N	N	N	N	F	N	**G**
Reflex + Raptor	14/2	3	F	P	F	F	**E**	**E**	**E**	F	**G**	**G**	**E**	F	P	F	P	P	P	N	N	N	P	N	P
Select Max	1	1	N	N	N	N	N	N	N	N	N	N	N	**E**	**G**	**E**	**E**	**E**	**E**	**E**	**E**	N	N	**G**	N
Varisto	2/6	2	**E**	F	**G**	**G**	**E**	**E**	F	**E**	**G**	N	**E**	P	P	F	P	P	P	P	P	N	**G**	N	F
Postemergence Layby[f]																									
Dual Magnum, others	15	2	N	P	N	P	F	**G**	P	P	N	**G**	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	P	N	N	N	**G**
Outlook	15	2	N	N	N	P	**G**	**G**	P	P	N	**G**	P	**E**	**E**	**E**	**E**	**E**	**G**	**G**	P	N	N	N	F

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

Herbicide Site of Action: The site of action key is located on pages 14-15. Herbicide Effectiveness: P=Poor; F=Fair; **G**=Good; **E**=Excellent; N=None; – = Not enough information to rank

* 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 (cold, wet); 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 Most horseweed populations in Michigan are resistant to ALS-inhibiting herbicides (Group 2). Herbicides that have this site of action group will not provide control and therefore are rated as no control. The best way to manage horseweed in dry beans is with tillage prior to planting.

[b] Control of hairy nightshade is **G**ood with Basagran and **E**xcellent with Pursuit or Raptor applied postemergence.

[c] Most waterhemp populations in Michigan are resistant to ALS-inhibiting herbicides (Group 2). Herbicides that have these site of action groups will not provide control and therefore are rated as no control.

[d] Outlook is best applied preplant incorporated. Preemergence applications can result in significant injury and delays in dry bean maturity.

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

[f] Postemergence Dual Magnum and Outlook will not control emerged weeds, but will provide resiudal control of the weeds listed above.

TABLE 5B — Dry Edible Bean Herbicides - Remarks and Limitations

Herbicide	Common Name	Site of Action Number	Application Timing	Rate/A	Trait
Assure II 0.88EC (others)	quizalofop	1	POST	7 fl oz + COC 1% v/v	N

- Assure II provides postemergence grass and volunteer corn control. Refer to Table 5A for weed control and crop tolerance ratings.
- Assure II rates range from 5 to 12 fl oz/A and are based on weed size and sensitivity. Refer to Table 2E for maximum weed sizes.
- Apply Assure II with COC (1% v/v) for best results. NIS (0.25% v/v) may replace COC for certain tank-mixtures (see label).
- Apply 5 fl oz/A of Assure II for volunteer corn control up to 18 inches tall; and 8 fl oz/A for corn up to 30 inches tall. Assure II will not control volunteer Enlist corn.
- Apply a minimum of 8 fl oz/A of Assure II for barnyardgrass and large crabgrass control.
- For perennial grass control, higher rates (10-12 fl oz/A) and sequential applications may be needed.
- Tank-mixtures of Assure II with certain postemergence broadleaf herbicides (Groups 6, 14 and certain Group 2 herbicides) can antagonize grass control.
- Applying Assure II either 1 day before or 7 days after the broadleaf herbicide will prevent the antagonism.
- Increasing the Assure II rate by 2 fl oz/A will also improve grass control in certain tank mixtures (i.e., Basagran).
- DO NOT tank-mix Assure II with Basagran and COC if the temperature exceeds 80 F, as excessive burn can occur.
- DO NOT apply more than two applications or 24 fl oz/A/year.
- Preharvest interval (PHI): 30 days
- Refer to Table 12 and the label for crop rotation restrictions.

Basagran 4L	bentazon	6	POST	1.5 pt + COC 1 qt	N
Basagran 5L	bentazon	6	POST	1.2 pt + COC 1 qt	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- Beans must have one fully expanded trifoliate before application.
- Most effective on small weeds. Basagran rates can be reduced to 1 pt/A (4L) or 0.8 pt/A (5L) if weeds are smaller than maximum growth stage (see label).
- AMS (2.5 lb/A) can be used instead of COC for improved velvetleaf control. If common ragweed and common lambsquarters are present a COC must also be included.
- Split applications of 1 pt + 1 pt (4L) or 0.8 pt + 0.8 pt (5L) plus COC (1 pt + 1 pt) can be used for more consistent common ragweed and common 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 COC (1 qt + 1 qt) when Canada thistle is 6-8 inches and yellow nutsedge is 4-6 inches tall. Make second application 7-10 days later.
- Adequate spray coverage is essential; a minimum of 20 gallons/A of spray solution is recommended.
- MSU research has shown significant dry bean injury from Basagran applications to Adzuki beans and does not recommend this application.
- Tank-mixtures of Basagran 4L at 8-16 fl oz or Basagran 5L at 6.4-12.8 fl oz with Raptor or Pursuit can minimize the risk of dry bean injury compared with either of these herbicides applied alone.
- DO NOT apply if dry beans are under stress from herbicide injury, cold or dry weather, or hail damage.
- DO NOT apply more than 4 pt/A/year (4L) or 3.2 pt/A/year (5L).
- Preharvest interval (PHI): 30 days
- Refer to Table 12 and the label for crop rotation restrictions.

TABLE 5B — Dry Edible Bean Herbicides - Remarks and Limitations

Herbicide	Common Name	Site of Action Number	Application Timing	Rate/A	Trait
Dual Magnum, EverpreX 7.62EC Dual II Magnum 7.64EC	s-metolachlor	15	PP, PPI, PRE	1.33 pt	N
			POST	1 pt	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- Application rates range from 1 to 2 pt/A and are based on soil texture and organic matter. Rates for course textured soils are 1 to 1.33 pt/A; medium soils 1.33 to 1.67 pt/A; and fine soils 1.33 to 1.67 pt/A with <3% OM; 1.67 to 2 pt/A >3% OM.
- Preplant incorporated (PPI) applications reduce the risk of injury to dry beans compared with PRE applications.
- DO NOT apply if soil is cracking and beans are in the crook stage.
- Preemergence applications require rainfall for incorporation. Rotary hoe if no rainfall occurs within 7 days.
- Dual provides better yellow nutsedge control than Outlook.
- Prowl, trifluralin or Sonalan can be tank-mixed preplant incorporated for lambsquarters control.
- Pursuit (2 fl oz) can be tank-mixed PRE for nightshade and additional broadleaf control.
- MSU research has shown significant dry bean injury from Dual applications to Adzuki beans and does not recommend this application.

Postemergence: Dual Magnum/Dual II Magnum can only be applied after the first trifoliate stage of growth (V1).

- Postemergence applications will not control emerged weeds, but will provide residual control of annual grasses and some broadleaf weeds, including waterhemp.
- Postemergence applications may result in temporary spotting or browning of dry bean leaves and stunting. Tank-mixtures with other herbicides may increase dry bean injury.
- DO NOT apply EverpreX postemergence. This application timing is currently not listed on the EverpreX label.
- DO NOT apply more than 2 pt/A/year total.
- Preharvest interval (PHI): 50 days
- Refer to Table 12 and the label for crop rotation restrictions.

Eptam 7EC	EPTC	15	PPI only	1.25 qt	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- Eptam needs to be incorporated immediately after application.
- Eptam suppresses common ragweed and wild mustard.
- Prowl, trifluralin or Sonalan should be tank-mixed with Eptam for additional broadleaf control, including lambsquarters.
- Pursuit (2 fl oz) can be added to tank-mixes with Prowl, trifluralin or Sonalan for nightshade control.
- Pursuit (2 fl 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.
- Preharvest interval (PHI): 45 days
- Refer to Table 12 and the label for crop rotation restrictions.

Fusilade DX 2EC	fluazifop	1	POST	12 fl oz + COC 1% v/v	N

- Fusilade DX provides postemergence grass and volunteer corn control. Refer to Table 5A for weed control and crop tolerance ratings.
- Fusilade DX rates range from 6 to 12 fl oz/A and are based on weed size and sensitivity. Refer to Table 2E for maximum weed sizes.
- Apply Fusilade with COC (1% v/v) for best results. NIS (0.25% v/v) may replace COC for certain tank-mixtures (see label).
- Apply 6 fl oz/A of Fusilade DX for volunteer corn control from 12 to 24 inches tall. Fusilade DX will not control volunteer Enlist corn.
- For perennial grass control, sequential applications (10-21 days apart) are needed; 12 followed by 8 fl oz/A or 16 followed by 14 fl oz/A for heavy grass pressure.
- Tank-mixtures of Fusilade DX with certain postemergence broadleaf herbicides (Groups 6, 14 and certain Group 2 herbicides) can antagonize grass control.
- Applying Fusilade DX either 1 day before or 7 days after the broadleaf herbicide will prevent the antagonism.
- DO NOT apply more than 24 fl oz/A per application or 48 fl oz/A/year to dry beans.
- Preharvest interval (PHI): 60 days
- Refer to Table 12 and the label for crop rotation restrictions.

TABLE 5B — Dry Edible Bean Herbicides - Remarks and Limitations

Herbicide	Common Name	Site of Action Number	Application Timing	Rate/A	Trait
Outlook 6EC	dimethenamid-P	15	PP, PPI, PRE	14 fl oz	N
			POST	10 fl oz	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- Application rates range from 12 to 21 fl oz/A and are based on soil texture and organic matter.
- PPI applications are safer to dry beans than PRE applications and therefore are recommended.
- 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 fl oz) can be tank-mixed for nightshade and additional broadleaf weed control.

Postemergence: Outlook can be applied from the first to the third trifoliate (V1-V3) stage of dry bean.
- Postemergence Outlook will not control emerged weeds but will provide residual control of annual grasses and some broadleaf weeds, including waterhemp.
- Postemergence applications may result in temporary spotting or browning of dry bean leaves and stunting. Tank-mixtures with other herbicides may increase dry bean injury.
- Outlook can be applied in two split-applications, 10 to 14 fl oz/A for the first application (PPI) and the remaining 7 to 11 fl oz/A POST, as long as the maximum application rate of 21 fl oz/A/year of Outlook is not exceeded.
- DO NOT use on adzuki beans.
- Preharvest interval (PHI): 70 days
- Refer to Table 12 and the label for crop rotation restrictions.

Permit, Sandea 75DF	halosulfuron	2	PP, PPI, PRE	0.67 oz	N
			POST	0.67 oz + NIS 0.25% v/v	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- Reduce the rate of soil-applied Permit/Sandea to 0.5 oz/A on lighter textured soils with low organic matter.
- Soil-applied Permit/Sandea can cause injury under cool-wet growing conditions and may delay dry bean maturity.
- Permit/Sandea applied PPI can be tank-mixed with Eptam for grass and additional lambsquarters control.
- Permit/Sandea can also be tank-mixed with PPI/PRE s-metolachlor products or Outlook for annual grass control.

Postemergence: Apply Permit/Sandea when beans have 1 to 3 trifoliates (V1-V3), but prior to flowering.
- Postemergence applications are most effective on small weeds (less than 2 inches).
- Permit/Sandea can be tank-mixed with other herbicides for additional broadleaf and grass control.
- DO NOT make more than one postemergence application per season.
- Dry bean varieties and classes vary in their tolerance to Permit/Sandea. 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 make more than two applications of 0.67 oz/A per crop cycle.
- Preharvest interval (PHI): 30 days
- DO NOT plant sugarbeets within 21 months of Permit application. Refer to Table 12 and the label for additional crop rotation restrictions.

Poast 1.5EC	sethoxydim	1	POST	16 fl oz + COC 1 qt + AMS 2.5 lb	N

- Poast provides postemergence grass and volunteer corn control. Refer to Table 5A for weed control and crop tolerance ratings.
- Poast rates range from 12 to 16 fl oz/A and are based on weed size and sensitivity. Refer to Table 2E for maximum weed sizes.
- Apply Poast with COC (1 qt/A) + AMS (2.5 lb/A) or MSO (1.5 pt) + AMS (2.5 lb/A) for best results.
- Apply 24 fl oz/A of Poast to control volunteer and interseeded small grains (barley, oats, rye, and wheat).
- Sequential applications 24 fl oz/A followed by 16 fl oz/A, 7-14 days apart are usually needed for perennial grass control.
- Poast is not as effective for control of volunteer corn or perennial grasses as the other postemergence grass herbicides.
- Tank-mixtures of Poast with certain postemergence broadleaf herbicides (Group 6, 14 and certain Group 2 herbicides) can antagonize grass control.
- Applying Poast either 1 day before or 7 days after the broadleaf herbicide will prevent the antagonism.
- DO NOT apply more than 40 fl oz/A per application or 64 fl oz/A/year.
- Preharvest interval (PHI): 30 days
- Refer to Table 12 and the label for crop rotation restrictions.

TABLE 5B — Dry Edible Bean Herbicides - Remarks and Limitations

Herbicide	Common Name	Site of Action Number	Application Timing	Rate/A	Trait
Prowl 3.3EC	pendimethalin	3	PPI only	2.4 pt	N
Prowl H_2O 3.8ACS	pendimethalin	3	PPI only	2 pt	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- Application rates range from 2.4 to 3.6 pt/A of Prowl 3.3EC and 2 to 3 pt/A of Prowl H_2O and are based on soil texture and organic matter.
- Prowl/Prowl H_2O should be incorporated immediately after application.
- Prowl/Prowl H_2O provides better velvetleaf control than trifluralin or Sonalan.
- Prowl/Prowl H_2O can be tank-mixed with Eptam. Other measures may need to be taken for additional broadleaf control.
- DO NOT make more than one application per season.
- Preharvest interval (PHI): none listed
- Refer to Table 12 and the label for crop rotation restrictions.

Pursuit 2L	imazethapyr	2	PP, PPI, PRE	2 fl oz	N
Pursuit 2L + Basagran 5L	imazethapyr + bentazon	2 6	POST	2 fl oz + 6.4 fl oz + NIS 0.25% v/v + AMS 2.5 lb	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- DO NOT not apply to sands or loamy sand soils or if cold and/or wet conditions are present or predicted to occur within one week of application.
- Pursuit may be applied PPI or PRE at rates up to 3 fl oz/A on heavy soils with greater than 2% organic matter and heavy weed pressure.
- Pursuit (2 fl oz) can be tank-mixed and applied PPI with Eptam plus trifluralin; Prowl or Sonalan; or Dual Magnum or Outlook; or PRE 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.

Postemergence: Apply Pursuit at rates up to 3 fl oz/A when beans have at least one fully expanded trifoliate (V1), but prior to flowering (R1).

- Postemergence applications are most effective on small weeds (less than 2 inches).
- At least 8 fl oz of Basagran 4L or 6.4 fl oz (5L) must be tank-mixed with Pursuit, if AMS is added. Basagran minimizes the risk of crop injury from this application.
- Increase the rate of Basagran to 16 fl oz (4L) or 12.8 fl oz (5L) when tank-mixed with Pursuit to control common cocklebur and jimsonweed, and to provide good control of common lambsquarters (less than 2 inch tall).
- Delayed maturity may result from applications of Pursuit. DO NOT apply if planting is delayed and frost is likely to occur prior to maturity.
- Dry bean varieties vary in their sensitivity to Pursuit. Use only on great northern, navy, black, pinto, red kidney, and cranberry beans.
- Pursuit can also be applied to adzuki beans.
- Pursuit can be tank-mixed with postemergence grass herbicides for volunteer corn control only.
- Preharvest interval (PHI): 60 days
- Pursuit is very persistent and can limit rotational crops. Rotation to sugarbeets, cucumbers, and tomatoes requires 40 months and a successful bioassay. Refer to Table 12 and the label for additional crop rotation restrictions.

TABLE 5B — Dry Edible Bean Herbicides - Remarks and Limitations

Herbicide	Common Name	Site of Action Number	Application Timing	Rate/A	Trait
Raptor 1SL + Basagran 5L	imazamox + bentazon	2 6	POST	4 fl oz + 6.4 fl oz + COC 1% v/v + AMS 2.5 lb	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- Apply Raptor at 4 fl oz/A when beans have at least one fully expanded trifoliate (V1), but prior to flowering (R1).
- Postemergence applications are most effective on small weeds (less than 2 inches).
- Apply Raptor with COC (1% v/v) or NIS (0.25% v/v).
- At least 8 fl oz of Basagran 4L or 6.4 fl oz (5L) must be tank-mixed with Raptor. Basagran minimizes the risk of crop injury from this application.
- Increase the rate of Basagran to 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). These rates of Basagran will antagonize grass control.
- Delayed maturity may result from applications of Raptor. DO NOT apply if planting is delayed and frost is likely to occur priot to maturity.
- Raptor can be applied to adzuki beans.
- DO NOT use the combination of Raptor + Basagran on adzuki beans. Basagran causes significant injury to adzuki beans.
- Raptor can be tank-mixed with postemergence grass herbicides for volunteer corn control only.
- DO NOT make more than one application of Raptor to dry beans per year.
- Preharvest interval (PHI): 30 days
- Refer to Table 12 and the label for crop rotation restrictions.

Reflex 2SL	fomesafen	14	PP, PRE	1 pt	N
			POST	1 pt + COC 1% v/v	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- Soil-applied 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 and other fomesafen products can only be applied at a maximum use rate of 1 pt/A every other year and only in the Lower Peninsula of Michigan.
- Reflex is best used postemergence in dry beans due to the limited amount that can be used per season.

Postemergence: Apply Reflex at rates up to 1 pt/A when beans have at least one fully expanded trifoliate (V1), but prior to flowering (R1).
- Postemergence applications are most effective on small weeds: common ragweed, pigweeds and waterhemp 4-inches tall or less and eastern black nightshade 2-inches tall or less.
- Reflex at 0.5 pt/A will control common ragweed 2-inches tall or less.
- NIS at 0.25-0.5% v/v or COC 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 NIS when tank-mixing with Raptor or Pursuit. DO NOT add AMS or 28% N or significant injury can occur.
- Tank-mixtures with other herbicides will be needed to broaden the spectrum of weed control. Tank-mixtures for postemergence grass control may lead to grass antagonism under certain conditions. Applying the postemeregence grass herbicide either 1 day before or 7 days after Reflex or Reflex tank-mixtures will prevent the antagonism.
- Reflex can be applied only in the Lower Peninsula of Michigan.
- DO NOT make more than one application of Reflex (1 pt/A) in consecutive years.
- Preharvest interval (PHI): 45 days
- Refer to Table 12 and the label for crop rotation restrictions.

TABLE 5B — Dry Edible Bean Herbicides - Remarks and Limitations

Herbicide	Common Name	Site of Action Number	Application Timing	Rate/A	Trait
Select Max 0.97EC	clethodim	1	POST	9 fl oz + NIS 0.25% v/v	N

- Select Max provides postemergence grass and volunteer corn control. Refer to Table 5A for weed control and crop tolerance ratings.
- Select Max rates range from 9 to 16 fl oz/A for annual grass and 12 to 32 fl oz/A for perennial grass control. Application rates are based on weed size and sensitivity. Refer to Table 2E for maximum weed sizes.
- COC/MSO (1% v/v) can replace NIS for certain tank-mixtures (see label).
- The addition of AMS 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.
- Apply 6 fl oz/A of Select Max for volunteer corn control up to 12 inches tall; 9 fl oz/A for corn up to 24 inches tall; and 12 fl oz/A for corn up to 36 inches tall. Select Max will control Enlist corn.
- For perennial grass control, higher rates (12 to 32 fl oz/A) and sequential applications may be needed.
- Tank-mixtures of Select Max with certain postemergence broadleaf herbicides (Group 6, 14 and certain Group 2 herbicides) can antagonize grass control.
- Applying Select Max either 1 day before or 7 days after the broadleaf herbicide will prevent the antagonism.
- Increasing the Select Max rate by 2 fl oz/A will also improve grass control in certain tank mixtures.
- DO NOT apply more than 32 fl oz/A per application and 64 fl oz/A/year.
- Preharvest interval (PHI): 30 days
- Refer to Table 12 and the label for crop rotation restrictions.

Sequence 5.25EW	glyphosate + s-metolachlor	9 15	PP, PRE	3 pt + AMS 17 lb/100 gal	N

- Sequence at 3 pt/A 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 s-metolachlor (Dual).
- 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.
- DO NOT exceed 1.91 lb ai/A/year of s-metolachlor.
- Make only one application per year.
- Preharvest interval (PHI): none listed
- Refer to Table 12 and the label for crop rotation restrictions.

Sonalan HFP 3EC	ethalfluralin	3	PPI only	2 pt	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- Incorporate Sonalan HFP in top 2 to 3 inches of soil within 2 days of application.
- Sonalan should be tank-mixed with Eptam. Other measures may need to be taken for additional broadleaf control.
- Sugarbeets may be planted 8 months after application only if the Sonalan is applied at 3 pt/A or less and the treated soil is moldboard-plowed to a depth of 12 inches. Refer to Table 12 and the label for additional crop rotation restrictions.

trifluralin 4EC (many)	trifluralin	3	PPI only	1 pt	N

- Refer to Table 5A for weed control and crop tolerance ratings.
- Incorporate trifluralin in the top 2 to 3 inches of soil within 24 hr after application.
- On sandy and sandy loam soils low in organic matter, use 0.5 lb ai/A (1 pt/A); on medium textured soils apply up to 1.5 pt/A; and on fine textured soil apply up to 2 pt/A.
- 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.
- Sugarbeets may be planted 12 months after application. Moldboard plowing to a depth of 12 inches is recommended to reduce the risk of crop inury. Refer to Table 12 and the label for additional crop rotation restrictions.

TABLE 5B — Dry Edible Bean Herbicides - Remarks and Limitations

Herbicide	Common Name	Site of Action Number	Application Timing	Rate/A	Trait
Varisto 4.18SL	bentazon + imazamox	6 2	POST	21 fl oz + COC 1% v/v + AMS 2.5 lb	N

- Apply Varisto after the first trifoliate leaf of dry bean has fully expanded (V1) up to flowering (R1). Refer to Table 5A for weed control and crop tolerance ratings.
- Varisto can be applied at rates from 16 to 21 fl oz/A. Varisto at 21 fl oz/A is equivalent to Basagran at 21 fl oz (4L) or 16.8 fl oz (5L) and 4 fl oz/A of Raptor.
- Best when applied to weeds 2 inches tall or less.
- Delayed maturity may result from applications of Varisto. DO NOT apply if planting is delayed and frost is likely to occur prior to maturity.
- DO NOT tank-mix with postemergence grass herbicides unless for volunteer corn – grass antagonism will occur.
- MSU research has shown significant dry bean injury from bentazon (Basagran) applications to Adzuki beans and does not recommend this application.
- DO NOT make more than one application of Varisto per season or apply more than 21 fl oz/A per season.
- Preharvest interval (PHI): 30 days
- Refer to Table 12 and the label for crop rotation restrictions.

TABLE 5C — Dry Edible Bean — Preharvest Applications

Herbicide	Common Name	Site of Action Number	Application Timing	Rate/A	Trait
Aim 2EC	carfentrazone	14	Preharvest	2 fl oz + MSO 1% v/v	N

- Apply when crop is mature – at least 80% of the pods are yellow or buck skin in color and only 30% of green leaves remain on the plant.
- AMS (2.5 lb/A) in addition to MSO may enhance performance.
- 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.
- Aim at 1 fl oz/A can be applied with glyphosate or Gramoxone to broaden the spectrum of weed control over Aim alone.
- It generally takes 7-10 days to reach maximum desiccation.
- Spray coverage is important - apply in a minimum of 10 gallons of water per acre (20 gal/A is recommended) - sequential applications may be needed.
- DO NOT apply more than 6.1 fl oz/A of Aim per season.
- Preharvest interval (PHI): 0 days

glyphosate (see Table 10)	glyphosate	9	Preharvest	0.75 lb ae (see Table 10) + AMS 17 lb/100 gal	N

- Glyphosate should only be used for weed desiccation and not dry bean desiccation. Glyphosate residues have been found in harvested beans if applications are made too early. Consequently, some dry bean purchasers will not accept beans treated with glyphosate, consult you buyer prior to using glyphosate as a preharvest treatment.
- See Table 10 for a list of glyphosate products, formulations, and rates. Not all glyphosate products are labeled as a preharvest treatment in dry beans - consult specific labels for legal applications. Roundup branded products are currently labeled.
- Apply when beans are in the hard dough stage (30% moisture or less).
- It generally takes 10-14 days to reach maximum weed desiccation.
- Spray coverage is important - apply in a minimum of 10 gallons of water per acre (20 gal/A is recommended).
- DO NOT apply glyphosate to beans grown for seed.
- Only one preharvest application of glyphosate can be made per year.
- Preharvest intervals (PHI): 7 days

Gramoxone SL 3.0L	paraquat	22	Preharvest	1.3 pt + NIS 0.25% v/v	N

- **Gramoxone is a restricted-use pesticide.** Certified applicators are required to complete a paraquat specific training prior to use of Gramoxone. The paraquat training course can be found 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% of the leaves are still green.
- Always add NIS at 0.25% v/v or COC at 1% v/v.
- If growth is lush and vigorous, make either a single application of 1.3 pt/A of Gramoxone SL; or split applications at 0.65 pt/A each. Split applications may improve vine coverage.
- Gramoxone is effective at desiccating glyphosate-resistant weeds and common lambsquarters.
- Gramoxone tank-mixtures with Sharpen at 1 fl oz/A are the most consistent and effective treatment for dry bean and weed desiccation.
- It generally takes 7-10 days to reach maximum desiccation.
- Spray coverage is important - apply in a minimum of 20 gallons of water per acre.
- DO NOT exceed 1.3 pt/A of Gramoxone SL 3.0 per year.
- Preharvest interval (PHI): 7 days

Sharpen 2.85SC	saflufenacil	14	Preharvest	1 fl oz + MSO 1% v/v + AMS 8.5 lb/100 gal	N

- Apply when crop is mature – at least 80% of the pods are yellowing and mostly ripe and no more than 40% of the leaves are still green.
- Sharpen can be applied at rates up to 2 fl oz/A.
- Sharpen is effective at desiccating glyphosate-resistant broadleaf weeds.
- Sharpen (1 fl oz/A) tank-mixtures with Gramoxone are the most consistent and effective treatment for dry bean and weed desiccation.
- It generally takes 7-10 days to reach maximum desiccation.
- Spray coverage is important - apply in a minimum of 10 gallons of water per acre (20 gal/A is recommended).
- DO NOT apply to beans grown for seed.
- DO NOT apply more than 2 fl oz/A/year of Sharpen for desiccation purposes.
- Preharvest interval (PHI): 2 days
- Refer to Table 12 and the label for crop rotation restrictions. DO NOT include time in the rotation interval when the ground is frozen.

TABLE 5C — Dry Edible Bean — Preharvest Applications

Herbicide	Common Name	Site of Action Number	Application Timing	Rate/A	Trait
Valor EZ 4SC	flumioxazin	14	Preharvest	1.5 fl oz + MSO 1 qt	N
Valor SX 51WDG	flumioxazin	14	Preharvest	1.5 oz + MSO 1 qt	N

- Apply when crop is mature – at least 80% of the pods are yellowing and mostly ripe and no more than 40% of the leaves are still green.
- Valor EZ and Valor SX can be applied at rates up to 3 fl oz/A and 3 oz/A, respectively.
- AMS (2.5 lb/A) in addition to MSO may enhance performance.
- Dry bean desiccation from Valor is similar to that from Gramoxone and glyphosate; however, the spectrum of weed control is not as broad.
- It generally takes 7-10 days to reach maximum desiccation.
- Spray coverage is important – apply in a minimum of 15 gallons of water per acre (20 gal/A is recommended).
- 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.
- Preharvest interval (PHI): 5 days
- Crop rotation restrictions are dependent on rainfall, 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 sugarbeets 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 sugarbeet no-till the spring following a Valor preharvest treatment resulted in major sugarbeet stand reduction. Tillage reduced the effect of Valor on sugarbeet; however, slight injury may occur on sandier soils. Refer to Table 12 and the label for additional crop rotation restrictions.

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 test	CEC	40 bu/a				60 bu/a			
		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 test	CEC	20 cwt/a				30 cwt/a			
		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.

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

MICHIGAN BEAN COMMISSION

Production Research Advisory Board

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!**

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