

## Final Report – 2021 (for Wyoming Bean Commission)

### Breeding Line Advancement – Powell REC

Jim Heitholt and Donna Harris

*Document was prepared in February 2022; Funding Awarded, \$6,250*

#### Introduction

Our UW research group has been developing and testing experimental lines for several years before and after the establishment of the Wyoming Bean Commission. Producers in Wyoming are interested in our research group's effort to release a new dry bean cultivar with earliness and high yield, hopefully in the very near future. Our LPID series of lines yield well but are not particularly early or very upright. In tests from 2019 to 2021, the LPID series of lines never led the yield test although they ranked no better or worse compared to the popular cultivars grown in Wyoming such as La Paz, Monterrey, Othello, Poncho, and Windbreaker.

#### Objectives

This project had four objectives that are covered in this report. These objectives were modified and expanded slightly from what we submitted as a proposal in February 2021.

First (Objective-One), we tested 120 single-plant selections from our 2020 plots (plant-to-row) in one-row plots and characterized yield, seed size (aka, number of seed per pound), flowering date, maturity dates, and upright stature.

Second (Objective-Two), we tested ~90 lines in one-row plots using methods as described for Objective-One. These Objective-Two lines were not single-plant selections but were instead derived from bulked populations developed in 2019 and 2020. Many of these Objective-Two entries were replicated in multiple one-row plots as opposed a single-row observation performed for Objective-One.

Third (Objective-Three), we tested three sets of our own sister lines at the late-generation stage in replicated field trials. These Objective-Three lines were originally derived from early-generation single-plant selections in 2018 and 2019 to create "Families." These subsequent generation families contained subfamilies which have been kept separated. Within a subfamily, all seed has been bulked in order to have enough seed to conduct plot testing as opposed to single-row testing. This approach created enough seed to have replicated plots of several distinct entries (but these are not yet pure lines) within three families (which we call Family One, Two, and Three for this report). Family One had 11 sets of lines/subfamilies, Family Two had 8 sets, and Family Three also had 8 sets of distinct lines. Within a Family, the subfamilies were designated as single letters or double letters A, B, C, DD, EE, FF, etc. based upon code used back in 2020.

Fourth, in the greenhouse, we crossed LPID-3, LPID-7 and LPID-7 with two promising upright and mid-maturity USDA-ARS lines (or with several upright, virus resistant super-early-maturing lines) in order to create new lines with improved upright stature and better viral resistance. There is nothing really to report here at this time except that we have seed from early-generation progeny in envelopes that we hope to advance in 2022.

Finally, another objective that was part of the original proposal included advancing and further testing three of our most-advanced breeding lines, LPID-3, LPID-7, and LPID-9. As mentioned in the "Introduction", these three LPID lines performed competitively, but not superior to, the top commercial pintos (La Paz, Monterrey, Othello, Poncho, Windbreaker) when tested in Powell during 2019 and 2020.

The results from the performance of these advanced LPID-series lines for 2021 are not reported here in this report but instead are reported in a separate 2021 WBC report (Effect of N Rate on Dry Bean Yield with and without Fertilizer K).

## Methods

### *Field*

For Objective-One, the single-plant-selection test, seed from 120 different entries was planted on 4 June 2021 in 22-inch rows in one-row plots. Seeding rate varied but plots were typically sown at about 50K to 80K seed per acre rate. Flowering date, maturity date, upright stature, yield, and seed size were recorded. Plots were furrow irrigated throughout the season approximately every ten days during July and August.

For Objective-Two, 180 plots were established by planting on 4 June 2021. Row spacing was also 22-inch and seeding rate was again about 50K to 80K seed per acre for one-row plots. Among the Objective-Two entries were seed derived from selected greenhouse-advanced seed that were F<sub>2</sub>- and F<sub>6</sub>-discards from Colorado State University. Objective-Two also included several of our own progeny lines (described later). Data collection and irrigation was performed as we did for Objective-One.

For Objective-Three, we grew three “trials” with “trial” indicating a subcomponent of three parallel seed advancements (i.e., the three families and their subfamilies described earlier in the “Objectives” section). It was during 2019 and 2020 that we advanced progeny from three separate crosses; thus, we have three groups of seed that we call “Families.” These trials (or families) are referred to later as Family One, Family Two, and Family Three. Within the Families, we generated subfamilies that are designated by letters (A, B, EE, FF, etc.). For trials/Families One, Two, and Three, we planted three sets of sister lines that we had assembled during the past two years. Planting date was 3 June 2021 for Trial/Family One and Trial/Family Two and 4 June 2022 for Trial/Family Three. Each trial had 30 plots. Plots for these trials were six-rows wide and 15-feet long so that canopy temperature could be recorded (Apogee MI 2H0 Infrared Thermometer). Dates of canopy temperature collection were 3 July, 9 July, 14 July, 21 July, 26 July, 2 Aug, and 10 Aug. Trial/Family One tested 11 lines/subfamilies, Trial Two tested 8 lines/subfamilies, and Trial Three tested 8 lines/subfamilies.

### *Greenhouse*

We grew several lines in the greenhouse in order to make F<sub>1</sub> crosses. Parents included LPID3, LPID7, LPID9, PT9-5-6, PT11-13-1, UC-Tiger’s Eye, UC-Southwest Red, UC-Southwest Gold. The UC lines mature earlier than Othello, Poncho, and Max so that is one reason they are part of our crossing block. We are not allowed to cross with Poncho or Max so those are never part of our parent pool. The UC lines happen to be low yielding when grown here at Powell but they stand upright. There is nothing yet to report on the outcome of these greenhouse crosses because we plan on growing out the progeny in 2022.

## Results

*Objective-One.* For the 120 lines tested in this Objective, we found 17 lines that produced a 40-bag yield or greater (Table 1). Six of these 17 met our arbitrary criteria of being early or mid-maturity and upright (these six are marked in green). In addition, 30 other lines yielded above 35-bags (not shown).

*Objective-Two.* Nineteen lines derived from 20-year-old seed (discarded from Colorado State program) showed high yield but all showed late maturity (Table 2). For progeny derived from our own crosses, we found 8 lines to yield greater than 40-bags but only 4 lines were early enough to interest us regarding future work (Table 3).

*Objective-Three.* For Family One, yields did not differ significantly among the 11 sister-line (subfamily) entries although there were numerical differences (Table 4). Yields (2513 to 3283 lbs/a) from Family One were generally lower than yields obtained in nearby plots. For example, yields of the pinto cultivars Othello, Poncho, and Windbreaker in nearby plots was 3553, 3430, and 3324 lbs/a, respectively. Flowering date, maturity date, and upright stature differed significantly among the 11 entries. Line F (highlighted in green) from Family One appears to us to be the most promising due to its earliness, yield, and average upright stature.

For Family Two, all four traits differed significantly among the eight lines/subfamilies (Table 5). Except for FF and GG, yields were greater across Family Two lines than for Family One. These yields were competitive with a nearby field trial that grew three of the region's top pintos (please see comparison to Othello, Poncho, and Windbreaker above). Perhaps line HH in Family Two is the most promising due to its yield, relative earliness, and decent upright stature. Lines BB and DD yielded high but are late maturing.

For Family Three, all test lines yielded high but differences were not significant (Table 6). Line KKKK appeared to be the most promising with a yield of 4193 lbs/a, a relative early maturity of 91 days, and nearly a perfect upright stature of 9.7.

*Canopy Temperature.* Correlations of yield vs. canopy temperature for showed several negative relationships for the subfamily plots within each Family when all 30 data points were considered (Table 7). When the average yields and average temperatures of each entry/subfamily were analyzed and plotted against each other, clean correlations were only observed for Families One and Two (Figs. 1, 2, and 3).

## **Discussion and Summary**

This series of breeding line advancements and our agronomic observations indicated that we have developed several progeny lines that could eventually have cultivar potential. Across the series of observations, we identified six lines under Objective-One and four lines under Objective-Two that are worth advancing and retesting. Within the three Family groups, we identified at least one line/subfamily within each of three Families that hold potential for subsequent advancement. Correlations between yield and canopy temperature were observed presumably due to the higher yielding canopies having a deeper root system and an ability to acquire more soil moisture than lower yielding canopies. However, we do not have root depth data to support this explanation.

Some readers of this document will rightfully question some of the high yields per acre we have presented in our results for Objective-One and Objective-Two. We do not have a full-proof explanation as this time but we believe that the high yield values (> 4000 lbs/a) are related to the plots in those particular tests being one-row plots. If positioned next to a small canopy entry, a late-maturing one-row plot may benefit from extra solar radiation and thus, produce an inflated yield. At the early-generation phase, we have little choice but to grow one-row plots. Going forward, we expect to grow these high-yielding lines in three-row or six-row plots at our first opportunity and we expect that yield values will be similar to our commercial standard check cultivars.

Table 1. Yield of plant-to-row of the highest-yielding progeny associated with Objective One from Powell in 2021. Seven entries displayed relatively good earliness and upright stature.

Code	Female Parent	Male Parent	Yield	Maturity	Upright	Notes
			lbs/a	dap		
422 C	NE9	PI 642108	4417	96	7	medium mat upright
422 F	NE9	PI 642108	4342	96	9	medium mat upright
423 F	NE9	PI 642108	4148	91	8	medium mat upright
429 F	CO46348	PI 661128	5171	112	6	late
431 A	NE9	PI 642108	4175	96	3	lodged
431 B	NE9	PI 642108	4091	96	2	late, lodged
431 C	NE9	PI 642108	4290	86	4	lodged
431 D	NE9	PI 642108	4190	96	6	late, lodged
432 A	NE9	PI 642108	4129	91	2	medium mat lodged
432 E	NE9	PI 642108	4158	91	4	lodged
434 E	NE50	PI 642108	4005	96	9	late, lodged
438 D	ND8	PI 136692	4149	101	4	late, lodged
439 A	NE5	PI 136692	4905	86	4	early, lodged
439 D	NE5	PI 136692	4182	96	7	medium mat upright
440 A	NE5	PI 136692	4653	96	6	medium mat upright
440 D	NE5	PI 136692	4176	91	4	lodged
440 F	NE5	PI 136692	4246	96	7	medium mat upright

Table 2. Yield of plant-to-row of the highest-yielding progeny associated with Objective Two from Powell in 2021. Parents are unknown to us.

Code	Yield	Maturity	Upright	Replicates	Notes
	lbs/a	dap		no.	
CO 20003-1	4666	112	5.0	2	Late
CO 20008-1	5138	na	9.0	1	Upright but late maturing
CO 20010-1	4448	na	Na	2	Late
CO 20011-1	4640	101	8.0	1	Upright but late maturing
CO 39690-25	4058	111	8.5	4	Upright but late maturing
CO 39703-23	4798	112	7.0	1	Upright but late maturing
CO 39709-1	4036	na	8.3	3	Upright but late maturing
CO 30709-19	4058	na	8.0	1	Upright but late maturing
CO 39719-17	5171	na	8.0	1	Upright but late maturing
CO 39721-23	5299	112	7.0	1	Upright but late maturing
CO 39721-5	4269	na	5.5	2	Late
CO 39726-3	4417	na	8.0	2	Upright but late maturing
CO 39727-12	4242	na	9.0	1	Upright but late maturing
CO 39729-7	4985	na	7.0	1	Upright but late maturing
CO 39731-10	4522	na	7.5	2	Upright but late maturing
CO 39732-15	4541	112	8.0	1	Upright but late maturing
CO 39738-14	4051	na	9.0	3	Upright but late maturing
CO 39738-29	4101	na	5.7	4	Upright but late maturing
CO 39742-15	4018	111	8.5	2	Upright but late maturing

Table 3. Yield of progeny from our own crosses associated with Objective Two.

Code	Female Parent	Male Parent	Yield	Maturity	Upright	Notes
			lbs/a	dap		
	LPID-3	CO 39739-8	4257	96	7.0	1 plot
	LPID-3	PT11-13-1	5504	96	4.7	3 plots
	LPID-3	PT9-5-6	4830	100	6.6	5 plots
	LPID-9	PT9-5-6	4223	96	5.5	2 plots
	PI 578273	PI 661667	4188	101	7.0	1 plot (black)
	PT11-13-1	LPID-2	4715	101	7.2	4 plots
	PT11-13-1	LPID-9	5291	111	8.7	3 plots
	PT9-5-6	LPID-7	5022	98	8.0	4 plots

Table 4. Yield, flowering date, maturity date, and upright stature of subfamily entries from Family One progeny. There were either 2 or 3 plots per entry.

<b>Code</b>	<b>Yield</b>	<b>Flowering Date</b>	<b>Maturity Date</b>	<b>Upright</b>
	lbs/a	dap	dap	
A	2860	49	91	6.0
B	2622	43	75	8.7
C	2810	43	80	5.5
D	3125	44	78	8.3
F	3283	43	77	7.0
P	2616	49	91	9.0
Q	2888	47	92	6.0
S	2825	48	94	9.7
T	2513	48	91	9.7
V	2912	49	94	9.3
W	2637	48	91	9.3
LSD (0.05)	ns	3	5	1.3

Table 5. Yield, flowering date, maturity date, and upright stature of the eight subfamilies within Family Two progeny. There were either 3 to 4 plots per entry.

<b>Code</b>	<b>Yield</b>	<b>Flowering Date</b>	<b>Maturity Date</b>	<b>Upright</b>
	lbs/a	dap	dap	
BB	3522	45	97	8.0
CC	3108	45	82	4.5
DD	3920	47	99	5.2
EE	3248	44	91	5.0
FF	1999	43	80	8.0
GG	2673	44	77	7.2
HH	3396	44	84	7.3
KK	3127	46	104	7.0
LSD (0.05)	817	2	4	1.9

Table 6. Yield, flowering date, maturity date, and upright stature of the eight subfamilies within Family Three progeny. There were either 3 to 4 plots per entry.

Code	Yield	Flowering Date	Maturity Date	Upright
	lbs/a	dap	dap	
KKKK	4193	43	91	9.7
LLLL	3682	46	96	5.5
MMMM	4074	44	95	6.0
NNNN	3826	46	100	4.5
PPPP	3325	43	94	4.5
QQQQ	3602	42	95	4.0
RRRR	3532	43	102	6.3
SSSS	4059	44	96	6.0
LSD (0.05)	ns	2	6	2.4

Table 7. Correlations (Pearson Product-Moment) between yield and canopy temperature for three dry bean progeny Families in 2021. Correlations were run on all 30 data points within a Family.

Sampling Date	Family One	Family Two	Family Three
3 July	- 0.19	- 0.18	- 0.43 *
9 July	0.39 *	0.12	- 0.33
14 July	- 0.35	- 0.63	- 0.46 *
21 July	0.39 *	- 0.24	- 0.12
26 July	- 0.72 **	- 0.54	- 0.24
2 August	- 0.48 **	- 0.43	- 0.35
10 August	- 0.40 *	- 0.72	- 0.19
Average	- 0.43 *	- 0.54	- 0.47 **

\* indicates the correlation was significant at the 5% level and \*\* indicates significance at the 1% level.

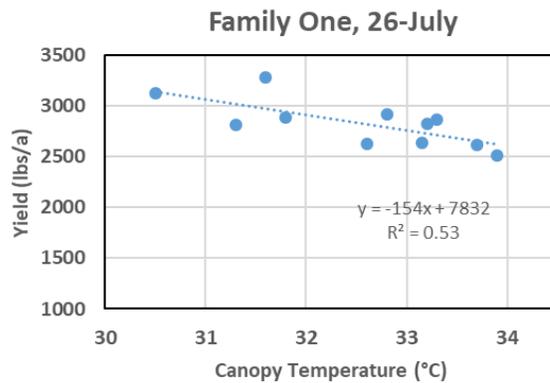


Figure 1. Relationship between the average yield of each Family One entry vs. average canopy temperature for entry in Powell on 26 July 2021.

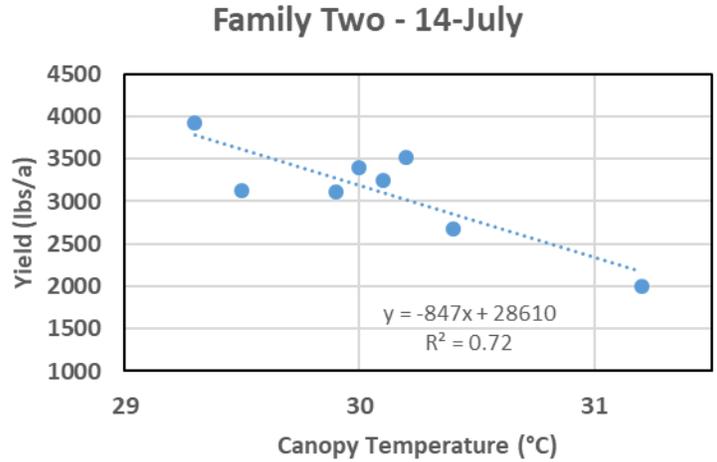


Figure 2. Relationship between the average yield of each Family Two entry vs. average canopy temperature for entry in Powell on 14 July 2021.

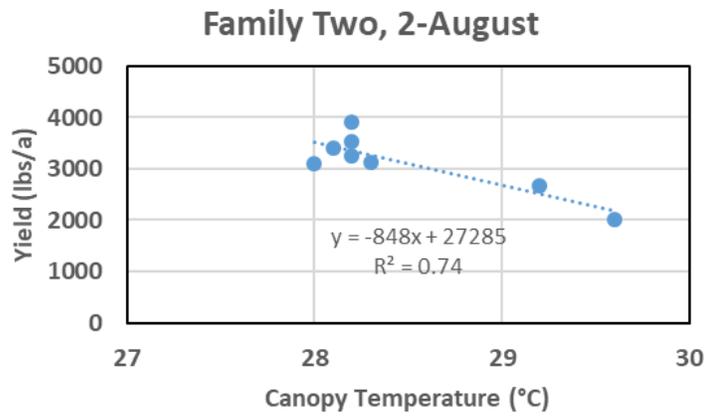


Figure 3. Relationship between the average yield of each Family Two entry vs. average canopy temperature for entry in Powell on 2 August 2021.