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MEMORANDUM

FROM: Liz Elmore and Jamie Sherman, Spring Barley
DATE: January 7, 2019
RE: Release of BUZZ (MT124112) spring malt barley

Pedigree: BUZZ = (ND7293/Bearpaw, Hockett)*4//(LK644, Lewis/Karl)

The variety is named after Buzz Mattelin, barley grower and supporter from eastern Montana.

Recommendation: Public, protected **Name:** BUZZ (MT124112)

Selection history:

MT124112 is a spring, 2-row, hulled barley developed for malt barley production in Montana. MT124112 has a lax head type, rough awns, white aleurone and long rachilla hairs. MT124112 is an F4 derived selection from backcrossing *GPC6H* into Hockett (ND7293/Bearpaw) four times. The original donor for *GPC6H* was Karl through an RIL from a Karl by Lewis cross (line number LK644). MT124112 was advanced by single seed descent from the F1 thru F4 generations. It was increased from a F4 plant to produce seed for preliminary yield testing in 2011. MT124112 was tested for agronomic and malt traits beginning in 2012. MT124112 was confirmed to carry the low protein allele for *GPC6H* via marker assisted selection (See et al., 2002).

Agronomic performance and characteristics:

Across all environments, MT124112 has substantially lower protein than the top performing malt varieties grown in Montana (Fig. 1). When MT124112 is compared to commonly grown lines, plump percentage and test weights are higher; heading dates are earlier while maturity dates are later; plant heights are shorter and less prone to lodging under irrigation (Tables 1A & B). Earlier heading dates and later maturity date increases time of grain fill by about five days (data not shown). The average yields of all lines reported are essentially equal when grown under the conservative nitrogen applications of malt barley production. However, MT124112 features a gene that consistently maintains malt-appropriate levels of grain protein under high fertilizer, thus displaying a substantially higher yield potential (Figure 2).

**DRYLAND
AGRONOMIC**

TRAITS	Variety	Variety Mean	MT124112	Percent of	P- value ¹	No. Locations
			Mean	Variety		
YIELD bu/ac	Growler	82.5	80.3	97%	0.0459	18
	Harrington	75.1	75.3	100%	0.8059	14
	Hockett	79.3	79.9	101%	0.3029	23
	Metcalfe	75.8	79.9	105%	0.0000	23
	Odyssey	83.9	81.0	97%	0.0065	14
	Synergy	81.9	80.3	98%	0.0185	18
PROTEIN AM ≤ 12% Adj ≤ 13%	Growler	13.0	11.4	88%	0.0000	18
	Harrington	13.3	11.6	87%	0.0000	14
	Hockett	12.4	11.3	91%	0.0000	23
	Metcalfe	13.2	11.3	86%	0.0000	23
	Odyssey	12.5	11.2	89%	0.0000	14
	Synergy	12.5	11.4	92%	0.0000	18
PLUMP AM & Adj >90%	Growler	83.6	90.8	109%	0.0000	18
	Harrington	81.5	88.8	109%	0.0000	14
	Hockett	88.1	91.0	103%	0.0000	23
	Metcalfe	83.3	91.0	109%	0.0000	23
	Odyssey	83.3	89.3	107%	0.0000	14
	Synergy	86.3	90.8	105%	0.0000	18
TEST WEIGHT lb/bu	Growler	50.8	53.0	104%	0.0000	18
	Harrington	51.9	52.7	102%	0.0000	14
	Hockett	53.1	52.9	100%	0.0108	23
	Metcalfe	52.5	52.9	101%	0.0000	23
	Odyssey	50.8	52.9	104%	0.0000	14
	Synergy	52.0	53.0	102%	0.0000	18
HEADING julian	Growler	176.4	173.2	98%	0.0000	12
	Harrington	174.0	171.0	98%	0.0000	14
	Hockett	173.6	171.9	99%	0.0000	18
	Metcalfe	173.5	171.9	99%	0.0000	18
	Odyssey	183.2	175.0	96%	0.0000	7
	Synergy	175.5	173.2	99%	0.0000	12
MATURITY julian	Growler	210.4	212.7	101%	0.0004	4
	Harrington	209.8	211.7	101%	0.0000	4
	Hockett	210.7	213.2	101%	0.0000	5
	Metcalfe	209.8	213.2	102%	0.0000	5
	Odyssey	220.5	218.3	99%	0.0025	2
	Synergy	210.5	212.7	101%	0.0000	4
HEIGHT cm	Growler	67.5	69.0	102%	0.0000	18
	Harrington	68.3	68.8	101%	0.0595	14
	Hockett	70.0	69.2	99%	0.0002	23
	Metcalfe	71.7	69.2	97%	0.0000	23
	Odyssey	61.7	68.6	111%	0.0000	14
	Synergy	70.5	69.0	98%	0.0000	18

Table 1A. 2015-18 Dryland agronomic measurements of the top performing varieties in Montana. As location years do not match for each comparison, MT124112 appears against each measured variety trait.

AMBA criteria for malting varieties: **AM** = All-Malt Brewing (barley only) **Adj.** = Adjunct Brewing

¹ Based on Fisher's LSD at the 0.05 probability level

**IRRIGATED
AGRONOMIC
TRAITS**

	Variety	Variety Mean	MT124112 Mean	Percent of Variety	P- value ¹	No. Locations
YIELD bu/ac	Growler	114.56	109.01	95%	0.0021	10
	Harrington	101.41	102.59	101%	0.3080	11
	Hockett	106.44	104.29	98%	0.0083	14
	Metcalfe	105.68	104.29	99%	0.0710	14
	Odyssey	116.66	109.72	94%	0.0000	7
	Synergy	111.91	109.01	97%	0.0179	10
PROTEIN AM ≤ 12% Adj ≤ 13%	Growler	11.27	11.08	98%	0.0074	10
	Harrington	11.7	10.82	92%	0.0000	11
	Hockett	11.87	11.11	94%	0.0000	14
	Metcalfe	11.87	11.11	94%	0.0000	14
	Odyssey	11.03	11.43	104%	0.0000	7
	Synergy	11.77	11.08	94%	0.0000	10
PLUMP AM & Adj >90%	Growler	94.55	96.12	102%	0.0000	10
	Harrington	92.11	95.88	104%	0.0000	10
	Hockett	93.93	96.09	102%	0.0000	13
	Metcalfe	93.1	96.09	103%	0.0000	13
	Odyssey	96.1	96.13	100%	0.8021	7
	Synergy	94.91	96.12	101%	0.0025	10
TEST WEIGHT lb/bu	Growler	51.5	52.55	102%	0.0000	10
	Harrington	52.77	52.49	99%	0.0037	10
	Hockett	52.95	52.17	99%	0.0000	13
	Metcalfe	52.71	52.17	99%	0.0000	13
	Odyssey	51.17	52.34	102%	0.0000	7
	Synergy	51.87	52.55	101%	0.0000	10
HEADING julian	Growler	180.76	175.19	97%	0.0000	7
	Harrington	176.2	171.47	97%	0.0000	10
	Hockett	175.88	173.21	98%	0.0000	11
	Metcalfe	176.58	173.21	98%	0.0000	11
	Odyssey	188.47	179.53	95%	0.0000	5
	Synergy	179.14	175.19	98%	0.0000	7
MATURITY julian	Growler	216	216.83	100%	0.2532	2
	Harrington	213.56	214.11	100%	0.0574	3
	Hockett	213	214.11	101%	0.0113	3
	Metcalfe	212.67	214.11	101%	0.0000	3
	Odyssey	226.33	225	99%	n/a	1
	Synergy	215.17	216.83	101%	0.0013	2
HEIGHT cm	Growler	76.78	77.06	100%	0.5181	10
	Harrington	80.19	78.32	98%	0.0001	11
	Hockett	80.27	78.51	98%	0.0000	14
	Metcalfe	81.88	78.51	96%	0.0000	14
	Odyssey	68.59	76.68	112%	0.0000	7
	Synergy	82.22	77.06	94%	0.0000	10
LODGING %	Growler	28.89	18.89	65%	0.0004	4
	Harrington	74.17	22.5	30%	0.0000	2
	Hockett	52.78	18.89	36%	0.0000	4
	Metcalfe	31.11	18.89	61%	0.0000	4
	Odyssey	24.17	22.5	93%	0.2645	3
	Synergy	31.67	18.89	60%	0.0000	4

Table 1B. 2015-18 Irrigated agronomic measurements of the top performing varieties in Montana. As location years do not match for each comparison, MT124112 appears against each measured variety trait.

¹ AMBA criteria for malting varieties: **AM** = All-Malt Brewing (barley only) **Adj.** = Adjunct Brewing
Based on Fisher's LSD at the 0.05 probability level

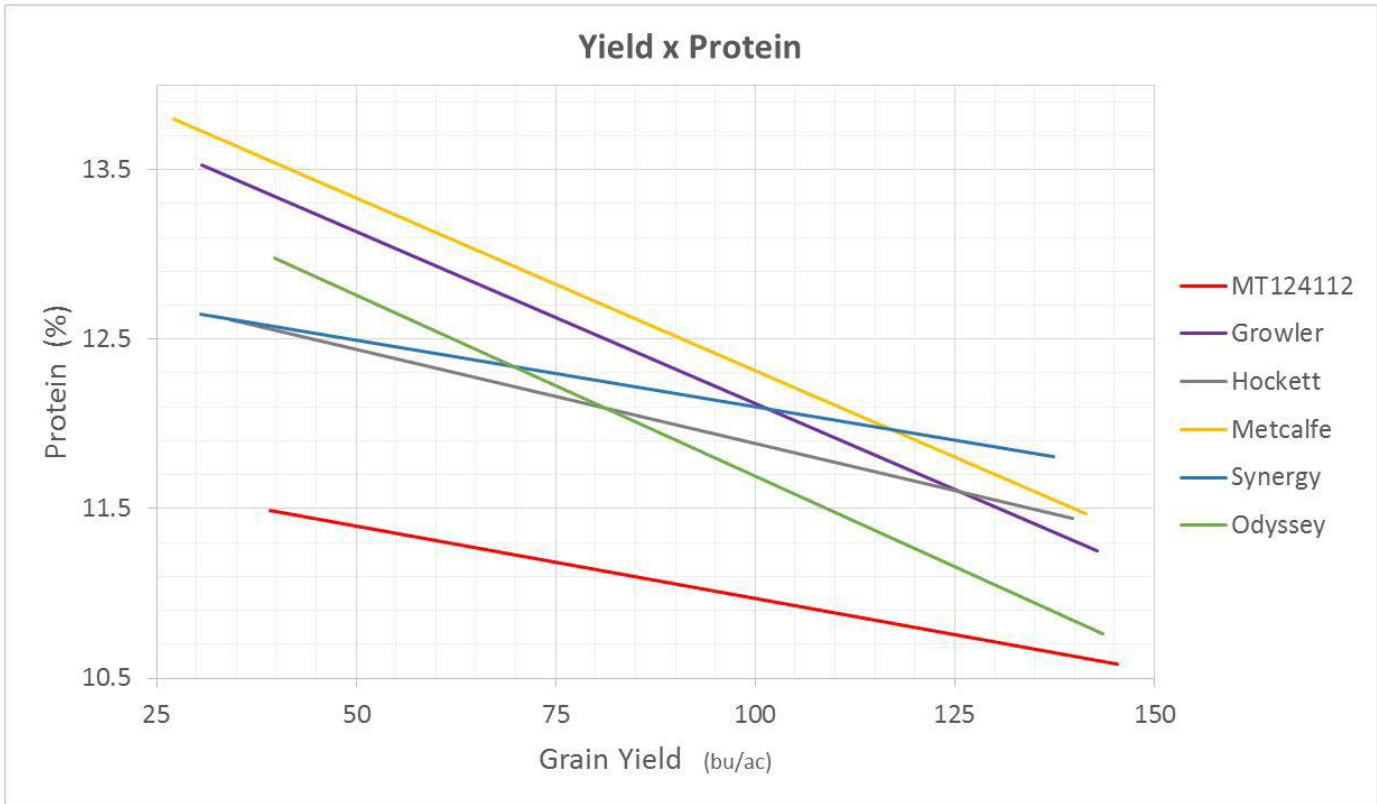


Figure 1. Data from all 2015-2018 Montana trials shows the consistency of MT124112’s low protein levels across a broad range of conditions (38 location years).

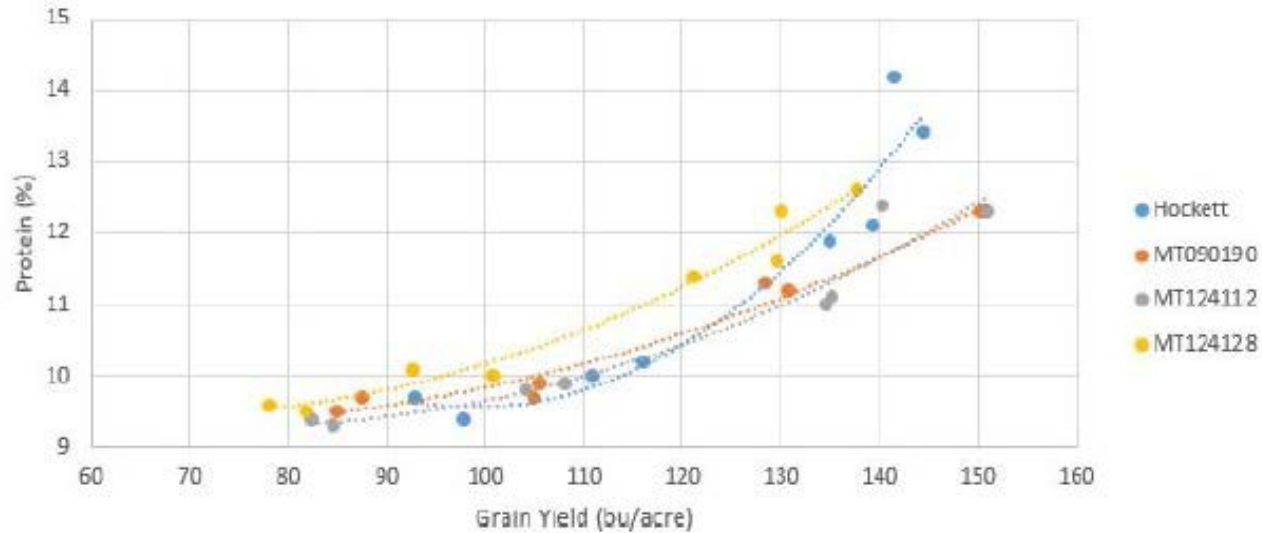


Figure 2. Data from a 6 location/year fertilizer management experiment with variable rates of nitrogen. The protein level of MT124112 increases more slowly with concurrent yield increases along the X axis. Note that the grain protein level for MT124112 grown at the highest yield potential was still acceptable, as were other malt quality parameters (not shown).

Malt quality characteristics:

The malt quality of MT124112 is suitable for both all-malt brewing (using only barley) as well as adjunct brewing. Generally, malting traits are either statistically equal or superior in performance according to the criteria determined by the American Malting Barley Association (AMBA). These traits stay within the acceptable ranges when grown under dryland or irrigated conditions.

Tables 2A & B show the malting traits compared with the other top performing malt varieties. MT124112 has higher malt extract and lower Beta glucan levels in dryland environments, and performs equally under irrigation. Diastatic power is consistently lower, making this line less enzymatically active than most commercially available lines, and thus ideal for all-malt brewing. Alpha amylase, free amino nitrogen, as well as various protein measurements (total malt, soluble, and soluble/total) are all statistically equal to other malting varieties.

When comparing MT124112's malt quality performance under rainfed or irrigated conditions, it appears that MT124112 performs better under rainfed, particularly in malt extract and beta glucan (Tables 2A & B). However, this difference is primarily due to the lab malting the line. The MSU malt quality lab follows a malt recipe more similar to that used by maltsters; while USDA-ARS has a different steeping regime. Steep regime highly impacts malt quality performance (Turner et al., submitted to ASBC). It happens that most of the dryland data was provided by MSU; while irrigated data was provided by USDA-ARS. Importantly, direct comparisons made here are under the same malting conditions.

MT124112's improved quality is in part due to faster hydration of the endosperm during malting. The Chapon Test, which steeps seeds for 48 hours, boils seed for 1 minute, and observes seed after splitting longitudinally, reveals the difficulty in hydrating Hockett's endosperm (Fig 3). Non-hydrated endosperm is white and chalky, while hydrated endosperm is gray and more translucent. In Figure 3, seeds from each line were grouped by visual scoring for their percent of hydrated endosperm. MT124112 has higher endosperm hydration than Hockett or Metcalfe after 48 hour steep under MSU malting conditions. Maltsters who use Hockett have requested a faster hydrating line, because slow hydration requires the addition of hormones for germination to proceed at an acceptable rate, costing time and money.

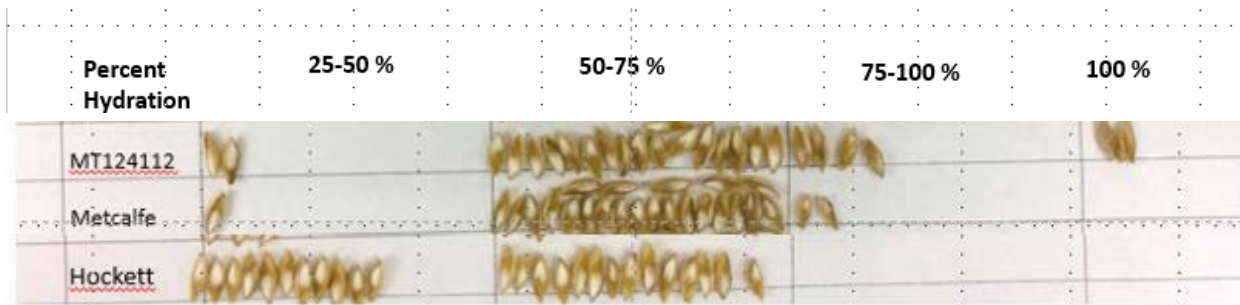


Figure 3: Percent hydration after 48 hours steep

**DRYLAND
MALT QUALITY**

TRAITS	Variety	Variety Mean	MT124112	Percent of	P- value ¹	No. Locations
			Mean	Variety		
MALT EXTRACT >81% for AM & Adj	Growler	78.6	82.2	105%	0.0263	3
	Harrington	79.0	82.2	104%	0.0199	3
	Hockett	80.1	82.2	103%	0.0049	3
	Metcalfe	80.4	82.2	102%	0.0129	3
	Odyssey	79.1	82.5	104%	0.0560	2
	Synergy	80.7	82.2	102%	0.0533	3
BETA GLUCAN <100 ppm for AM & Adj	Growler	120.2	85.5	71%	0.4388	3
	Harrington	256.3	85.5	33%	0.0155	3
	Hockett	216.0	85.5	40%	0.0638	3
	Metcalfe	52.8	85.5	162%	0.2961	3
	Odyssey	123.4	66.0	54%	0.3858	2
	Synergy	32.0	85.5	267%	0.0961	3
ALPHA AMYLASE AM 40-70 DU Adj >50 DU	Growler	106.8	119.0	111%	0.2036	3
	Harrington	84.8	119.0	140%	0.0905	3
	Hockett	89.0	119.0	134%	0.0585	3
	Metcalfe	105.3	119.0	113%	0.2435	3
	Odyssey	54.5	127.3	234%	0.0723	2
	Synergy	97.6	119.0	122%	0.0798	3
DIASTATIC POWER °ASBC AM 110-150 ° Adj >120°	Growler	195.3	133.0	68%	0.0123	3
	Harrington	163.7	133.0	81%	0.0091	3
	Hockett	168.0	133.0	79%	0.0115	3
	Metcalfe	171.0	133.0	78%	0.0156	3
	Odyssey	124.3	129.7	104%	0.3837	2
	Synergy	145.8	133.0	91%	0.2135	3
FREE AMINO NITROGEN AM 140-190 Adj > 210	Growler	206.3	212.7	103%	0.5760	3
	Harrington	193.8	212.7	110%	0.2041	3
	Hockett	166.2	212.7	128%	0.0841	3
	Metcalfe	219.5	212.7	97%	0.6259	3
	Odyssey	124.1	210.6	170%	0.0736	2
	Synergy	196.5	212.7	108%	0.3370	3
TOTAL MALT PROTEIN AM ≤ 11.8 % Adj ≤ 12.8 %	Growler	14.7	12.0	82%	0.0684	3
	Harrington	14.2	12.0	85%	0.0089	3
	Hockett	13.2	12.0	91%	0.0377	3
	Metcalfe	13.9	12.0	87%	0.0116	3
	Odyssey	13.7	11.8	86%	0.2338	2
	Synergy	12.9	12.0	93%	0.0291	3
SOLUBLE PROTEIN AM < 5.3 % Adj 4.8 - 5.6%	Growler	4.6	4.7	101%	0.7418	3
	Harrington	4.4	4.7	106%	0.0572	3
	Hockett	4.2	4.7	112%	0.0131	3
	Metcalfe	4.8	4.7	98%	0.0000	3
	Odyssey	3.7	4.6	126%	0.0997	2
	Synergy	4.6	4.7	102%	0.1835	3
S/T PROTEIN AM 38-45% Adj 40-47 %	Growler	32.6	40.3	124%	0.0204	3
	Harrington	32.1	40.3	126%	0.0065	3
	Hockett	32.7	40.3	123%	0.0021	3
	Metcalfe	35.8	40.3	113%	0.0175	3
	Odyssey	27.7	41.0	148%	0.0430	2
	Synergy	37.6	40.3	107%	0.0104	3

Table 2A. 2015-18 Dryland malt quality measurements of the top performing varieties in Montana. As location years do not match for each comparison, MT124112 appears against each measured variety trait.

AMBA criteria for malting varieties: **AM** = All-Malt Brewing (barley only) **Adj.** = Adjunct Brewing

¹ Based on Fisher's LSD at the 0.05 probability level

**IRRIGATED
MALT QUALITY
TRAITS**

	Variety	Variety Mean	MT124112 Mean	Percent of Variety	P- value ¹	No. Locations
MALT EXTRACT >81% for AM & Adj	Growler	81.3	81.3	100%	0.9493	3
	Harrington	80.9	81.5	101%	0.5273	5
	Hockett	81.2	81.5	100%	0.6493	5
	Metcalfe	81.6	81.5	100%	0.7931	5
	Odyssey	81.0	80.4	99%	0.5844	2
	Synergy	81.6	81.3	100%	0.7178	3
BETA GLUCAN <100 ppm for AM & Adj	Growler	133.1	183.3	138%	0.2530	3
	Harrington	260.9	162.2	62%	0.1999	5
	Hockett	218.5	162.2	74%	0.4502	5
	Metcalfe	100.4	162.2	162%	0.1365	5
	Odyssey	108.2	215.2	199%	0.4065	2
	Synergy	115.0	183.3	159%	0.0282	3
ALPHA AMYLASE AM 40-70 DU Adj >50 DU	Growler	95.8	115.4	120%	0.1266	3
	Harrington	81.2	112.5	139%	0.0123	5
	Hockett	93.7	112.5	120%	0.1892	5
	Metcalfe	103.0	112.5	109%	0.3391	5
	Odyssey	57.7	106.2	184%	0.1643	2
	Synergy	103.7	115.4	111%	0.3891	3
DIASTATIC POWER °ASBC AM 110-150 ° Adj >120°	Growler	150.8	129.9	86%	0.2295	3
	Harrington	144.6	135.5	94%	0.4940	5
	Hockett	163.9	135.5	83%	0.0042	5
	Metcalfe	152.9	135.5	89%	0.3192	5
	Odyssey	130.0	135.7	104%	0.4123	2
	Synergy	154.7	129.9	84%	0.2060	3
FREE AMINO NITROGEN AM 140-190 Adj > 210	Growler	215.9	230.6	107%	0.2947	3
	Harrington	201.1	240.0	119%	0.0054	5
	Hockett	228.4	240.0	105%	0.5439	5
	Metcalfe	250.4	240.0	96%	0.6463	5
	Odyssey	145.8	233.5	160%	0.0380	2
	Synergy	217.2	230.6	106%	0.1570	3
TOTAL MALT PROTEIN AM ≤ 11.8 % Adj ≤ 12.8 %	Growler	12.8	12.3	96%	0.2167	3
	Harrington	12.0	12.2	102%	0.7668	5
	Hockett	12.8	12.2	95%	0.0744	5
	Metcalfe	12.2	12.2	100%	0.9652	5
	Odyssey	12.8	13.0	102%	0.2952	2
	Synergy	12.6	12.3	98%	0.7280	3
SOLUBLE PROTEIN AM <5.3 % Adj 4.8 - 5.6%	Growler	4.8	5.0	104%	0.0117	6
	Harrington	4.9	5.3	108%	0.0001	8
	Hockett	5.1	5.3	103%	0.0570	8
	Metcalfe	5.1	5.3	102%	0.0896	8
	Odyssey	4.1	5.0	122%	0.0000	5
	Synergy	5.1	5.0	99%	0.3144	6
S/T PROTEIN AM 38-45% Adj 40-47 %	Growler	39.6	42.9	108%	0.2090	3
	Harrington	42.0	45.4	108%	0.1194	5
	Hockett	41.9	45.4	108%	0.0444	5
	Metcalfe	44.1	45.4	103%	0.4564	5
	Odyssey	34.3	40.6	118%	0.0604	2
	Synergy	42.5	42.9	101%	0.6761	3

Table 2B. 2015-18 Irrigated malt quality measurements of the top performing varieties in Montana. As location years do not match for each comparison, MT124112 appears against each measured variety trait. AMBA criteria for malting varieties: **AM** = All-Malt Brewing (barley only) **Adj.** = Adjunct Brewing

¹ Based on Fisher's LSD at the 0.05 probability level

Disease resistance:

Since 2015, trials have not had consistent disease pressure for disease scoring, although occasional observations of rust and leaf spots occur in Sidney under irrigation. We have ongoing trials in Sidney and North Dakota evaluating fusarium infections with subsequent DON (deoxynivalenol) testing by North Dakota State University. Not surprisingly, MT124112 responds to head blight similarly to Hockett.

Screening for Fusarium head blight resistance in ND						
	Langdon2015		Fargo2016		Langdon2016	
ID	% Severity	DON ppm	% Severity	DON ppm	% Severity	DON ppm
Craft	16.5	20.5	27.7	35.4	30.0	83.7
Haxby	23.3	12.4	30.0	11.6	36.7	74.3
Hays	30.0	19.0	30.0	8.1	60.0	69.9
Hockett	10.0	14.9	30.0	9.7	50.0	59.3
MT124112	30.0	15.4	36.7	29.5	53.3	43.7

Table 3. Rates of DON accumulation over three years of testing. Analysis fails to show statistically significant differences over time. For brewing, the tolerance is <1ppm DON.

Purification/seed stocks: We purified MT124112 in 2017 by planting 100 F9-derived F10 headrows at Bozeman Post farm. We evaluated for phenotypic uniformity before bulking all headrows. The 2018 breeder strips appeared uniform and were regularly rogued by barley breeding employees and Foundation staff.

Summary:

MT124112 is well-suited for production across all malt barley growing regions of Montana.

Agronomic Strengths

- Low grain protein in dry land and with higher nitrogen applications
- Can be grown at higher yield potential without damaging quality
- Shorter plant height and low percentage of lodging under irrigation
- Longer grain fill period
- Higher test weights and percentage of plump seed

Quality Strengths

- High Malt Extract
- Low DP value
- Low Beta glucan
- Faster hydration
- More stable quality across variable growing conditions

MSU Barley Breeding Program:

Jamie Sherman, PI

MSU Breeding Staff - Liz Elmore, Ron Ramsfield, Joe Jensen, Jessica Williams, Andrew Burkhart, Traci Hoogland, Megan Getz, Dylan Mangel, Jay Kalous, Ali Brunke, John Corbett, Nathan Sickler, and Kristal Kiel and the early breeding work done on this line by Tom Blake.

MSU Malt Quality Laboratory - Hannah Turner, Sarah Olivo, Kia Simshaw

Data Provided By:

MAES Research Centers Current and Former Staff/Faculty:

SARC - Ken Kephart, Kent McVay, Qasim Khan, Valerie Smith

NARC - Darin Boss, Peggy Lamb

WTARC - Gadi Reddy, John Miller

CARC - Patrick Carr, Jed Eberly, David Wichman

EARC - Chengci Chen, Frankie Crutcher, Calla Kowatch

NWARC - Jessica Torrior, Bob Stougaard, Brooke Bohannon

WARC- Zach Miller, Kyrstan Hubbel, Marty Knox

MSU Cereal Quality Lab - Deanna Nash, Harvey TeSlaa

USDA-ARS Malt Quality Lab, Madison WI; Jason Walling and Chris Martens

North Dakota State University - Robert Brueggeman, Patrick Gross, Rich Horsley and Paul Schwarz

Support and Assistance:

Irene Decker, Jim Berg, Doug Holen, Karen Maroney, Jack Martin, Jennifer Lachowiec, David Baumbauer, Perry Miller, Jeff Holmes, Mary Burrows, Monica Brelsford, Heather Unverzagt, Phil Bruckner, Kevin McPhee, Derek Lewis, Luther Talbert, Hwa Young Heo, Jason Cook, Andreas Fischer, Deanna Crow, Autumn Weis, John Sherwood, Mike Giroux, Andy Hogg, Jeff Johnston, and Craig Cook.

Critical Financial Support:

Montana Wheat and Barley Committee

American Malting Barley Association

Brewers Association

USDA

MSU Fertilizer Advisory Committee

New Belgium Brewing

American Society of Brewing Chemists

US Wheat and Barley Scab Initiative