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## **MEMORANDUM**

**TO:** Wheat Variety Release Committee

**FROM:** Hwa-Young Heo and Jason Cook, Spring Wheat Breeders

**DATE:** January 24<sup>th</sup>, 2024

**RE:** Proposal for MAES release of MT2050 for licensing

The following motion and supporting documentation are presented for consideration at the 2024 MAES Variety Release Meeting in Bozeman, MT:

**Motion:** Release MT2050 hard red spring wheat for licensing.

**Pedigree:** MT 1542/MT 1415

**Breeder Seed Available:** 9 Bushels, Additional breeder seed increase growing in Yuma, AZ.

## **CONTRIBUTORS**

- Dr. Jason Cook, Ms. Nancy Blake, Mr. Jared Lile, Ms. Mei Ling Wong, Ms. Deanna Nash, Dr. Hwa-Young Heo, MSU Bozeman, MT
- Dr. Jed Eberly, MSU-CARC, Moccasin, MT
- Dr. Chengci Chen, and Dr. Frankie Crutcher, MSU-EARC, Sidney, MT
- Ms. Peggy Lamb MSU-NARC, Havre,
- Dr. Kent McVay, MSU-SARC, Huntley, MT
- Dr. Justin Vetch MSU-WTARC, Conrad, MT
- Dr. Jessica Torrion MSU-NWARC, Creston, MT
- Mr. Doug Holen, MSU Foundation Seed, Bozeman, MT
- Mr. Craig Cook and Mr. Donny Gray, 2nd Nature Research, LLC, Bozeman, MT
- Dr. Dale Clark and Mr. Trevor Schafer, Nutrien Ag Solutions, Bozeman, MT
- Dr. Xianming Chen USDA-ARS, Pullman, WA
- Dr. Matthew Rouse, USDA-ARS, St. Paul, MN
- Dr. Jason Fiedler, USDA-ARS, Fargo, ND
- Dr. Mike Pumphrey, WSU, Pullman, WA
- Dr. Zhaohui Liu, NDSU, Fargo, ND

**Summary:** MT2050 is a moderately sawfly resistant line that has good straw strength overall. Yield is good in Montana rainfed and irrigated environments, test weight is good and grain protein content is slightly higher than Vida. MT 2050 is moderately resistant to stripe rust and threshes better than 'Duclair' (Lanning et al., 2011).

### **Breeding History and Agronomic Performance:**

MT2050 is a cultivar derived from the cross MT1542/MT1415. MT1542 was an MAES experimental line resulting from the cross between CHSY-26 and 'Choteau' (Lanning et al., 2004), with CHSY-26 being a recombinant inbred line (RIL) selected from a genetic mapping population developed from the cross Choteau/'S-Yellowstone' (Blake et al., 2011). This cross aimed to identify a quantitative trait locus (QTL) associated with yield component traits (Cook et al., 2018). 'S-Yellowstone' was developed by the Montana State University spring wheat breeding program to investigate winter wheat yield component alleles in spring wheat. This was achieved by backcrossing the Vrn-A1 spring growth habit allele into the winter wheat variety 'Yellowstone' (Bruckner et al., 2007). 'Yellowstone' was released by the Montana Agricultural Experiment Station (MAES) in 2005 due to its high yield potential and broad adaptation to Montana's winter wheat growing environments, making it one of the most widely cultivated winter wheat varieties in the region for several years. 'Choteau,' released by MAES in 2003, was released for having sawfly resistance and superior yield compared to other solid stem spring wheat varieties of that time. Lastly, MT0516 was an MAES spring wheat experimental line contributing to the breeding lineage.

MT1415 was an MAES experimental line derived from the cross 'Vida' (Lanning et al., 2006)/MT0909. 'Vida' was released by MAES in 2006 for its high yield in rainfed environments and is the most widely grown spring wheat variety in Montana. MT0909, another MAES experimental line, was not released.

Data from the Advanced Yield Trial (AYT) collected during the 2021 to 2023 growing seasons, across 34 location-years (26 rainfed and 8 irrigated environments), evaluated the performance of MT2050. In rainfed conditions, MT2050 exhibited an average yield performance 2.3 bu/ac higher than Duclair but 2.6 bu/ac lower than Dagmar (Table 1). Analyzing all location-years, MT2050 was in the top statistical yield group in 8 out of 12 locations (Table 2). Regarding grain protein content, MT2050 demonstrated a 0.2% increase compared to Vida but was 0.5% lower than 'Dagmar' (Heo et al., 2020) (Table 3). Test weight was 59.7 lbs/bu across all environments (Table 4). In terms of phenology, MT2050 exhibited heading and maturity dates 0.9 days and 1.8 days earlier than Vida, respectively (Table 4). Solid-stem scores for MT2050, Duclair, and Dagmar were 19.0, 19.3, and 17.4, respectively. Sawfly cutting data collected from Fort Benton, MT was 24.2%, 19.8%, and 23.9% for MT2050, Duclair, and Dagmar, respectively (Table 4). At Havre, MT, sawfly cutting for MT2050, Duclair, and Dagmar were 12.5%, 3.9%, and 2.7%, respectively. MT2050 is assessed

to be moderately resistant to sawfly. Lastly, MT2050 is susceptible to plant available aluminum (Table 4).

Data gathered from 28 Off-Station Yield Trials, comprising 21 rainfed and 7 irrigated environments during the 2022-2023 growing season, facilitated additional comparisons between MT 2050 and commonly grown varieties in Montana (Table 5). Across all environments, MT2050 was in the top-yielding statistical group, although it exhibited a yield 2.3 bu/ac lower than Dagmar. Sawfly cutting observations were made at seven locations, where MT2050 was cut 14.0%, while Duclair and Dagmar were cut 12.3% and 12.6%, respectively. Falling numbers were obtained from nine off-station environments, indicating that MT 2050 had an overall falling number of 409, which was below average (417) across all lines.

MT2050 underwent evaluation in various disease screening nurseries. In terms of prevalent races of *P. tritici-repentis* and the predominant North Dakota *Septoria nodorum* isolate, MT2050 was found to be moderately susceptible (Table 6). Susceptibility to fusarium head blight was observed over three years of testing at the Eastern Ag Research Center (Table 7). Stripe rust screening over multiple years in Washington indicate MT2050 is moderately resistant. Stripe rust resistance was likely inherited from Yellowstone (Table 8).

End-use quality of MT2050 was assessed at eight AYT locations during the 2021 - 2023 growing seasons. Among the 32 lines compared, MT2050 exhibited higher mixing tolerance than Vida but slightly lower bake water absorption (Table 9). In comparison to Dagmar and Duclair, both mixing tolerance and water absorption for MT2050 were lower. Overall, the end-use quality of MT2050 was found to be similar to that of Vida.

## References:

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Table 1. Grain yield (bu/ac) comparisons between MT2050 and common varieties grown in 26 Advanced Yield Trial (AYT) rainfed location-years from 2021 to 2023. Thirty-two common varieties were grown in all three years and were included in the combined analysis. Bold values indicate varieties were not significantly different from the highest yielding line. Table sorted based on combined means.

Loc.	Bozeman (rainfed)	Havre	Huntley/ Billings	Moccasin	Conrad	Sidney (rainfed)	Fort benton	Hingham	Williston	Overall Mean
Year	2021-2023	2021-2023	2021-2023	2021-2023	2021, 2023	2021-2023	2021-2023	2021-2023	2021-2023	N = 26
MT CARLSON	<b>95.5</b>	<b>38.3</b>	<b>68.0</b>	<b>35.3</b>	<b>58.6</b>	<b>64.0</b>	<b>48.8</b>	<b>37.7</b>	<b>42.5</b>	<b>54.3</b>
MT DUTTON	<b>95.4</b>	<b>40.0</b>	<b>67.6</b>	<b>33.1</b>	<b>51.3</b>	<b>65.0</b>	<b>47.3</b>	<b>39.5</b>	<b>45.0</b>	<b>53.8</b>
DAGMAR	<b>91.2</b>	<b>41.6</b>	<b>67.5</b>	<b>36.4</b>	<b>54.6</b>	<b>65.7</b>	<b>45.3</b>	<b>34.6</b>	<b>41.4</b>	<b>53.1</b>
MT 2030	<b>96.1</b>	36.0	<b>64.4</b>	<b>35.6</b>	<b>52.8</b>	<b>66.7</b>	<b>48.8</b>	<b>37.4</b>	36.1	<b>52.7</b>
VIDA	<b>89.8</b>	<b>38.4</b>	<b>67.0</b>	<b>33.2</b>	47.7	<b>63.2</b>	<b>49.6</b>	<b>38.9</b>	<b>42.4</b>	<b>52.2</b>
ROCKER	<b>92.1</b>	<b>39.2</b>	<b>66.9</b>	<b>32.8</b>	<b>50.8</b>	60.3	<b>49.0</b>	34.0	<b>40.3</b>	<b>51.7</b>
LCS ASCENT	<b>95.2</b>	<b>37.0</b>	<b>62.2</b>	<b>33.5</b>	<b>53.6</b>	<b>64.4</b>	41.1	34.2	<b>43.3</b>	<b>51.6</b>
MT 2049	<b>91.2</b>	<b>38.4</b>	<b>63.5</b>	<b>36.7</b>	49.5	<b>62.6</b>	43.9	<b>35.6</b>	<b>41.6</b>	51.4
WB 9516	<b>92.8</b>	<b>37.5</b>	<b>65.7</b>	26.2	<b>55.4</b>	59.9	<b>46.6</b>	<b>34.4</b>	37.2	50.6
<b>MT 2050</b>	87.6	<b>39.8</b>	<b>63.3</b>	<b>32.9</b>	<b>52.6</b>	60.1	<b>47.1</b>	34.1	36.9	50.5
LANNING	88.3	35.6	<b>62.8</b>	<b>33.0</b>	<b>50.7</b>	<b>62.7</b>	<b>45.8</b>	32.2	<b>40.1</b>	50.1
MT SIDNEY	<b>90.2</b>	33.5	<b>65.3</b>	<b>32.4</b>	50.3	61.9	43.4	33.6	<b>39.7</b>	50.0
SY ROCKFORD	<b>91.9</b>	<b>38.6</b>	<b>64.2</b>	<b>32.4</b>	<b>52.2</b>	60.4	37.1	29.4	<b>40.5</b>	49.6
WB 9719	<b>91.7</b>	35.1	<b>58.8</b>	26.6	50.4	59.9	<b>44.8</b>	<b>35.2</b>	<b>38.5</b>	49.0
REEDER	86.5	35.5	<b>61.6</b>	29.6	48.9	59.1	41.9	<b>35.5</b>	36.6	48.4
WB GUNNISON	80.2	<b>40.2</b>	58.1	27.4	<b>51.9</b>	54.1	<b>44.7</b>	<b>39.6</b>	<b>38.7</b>	48.3
DUCLAIR	<b>90.2</b>	34.3	<b>64.5</b>	<b>30.6</b>	45.2	52.6	44.2	<b>34.4</b>	37.5	48.2
SY LONGMIRE	85.3	33.1	<b>66.2</b>	24.9	49.1	55.9	<b>44.9</b>	33.9	<b>39.8</b>	48.1
CORBIN	78.3	35.7	57.0	27.6	<b>52.3</b>	52.9	42.1	<b>36.6</b>	36.6	46.6
AP SMITH	83.5	32.8	<b>61.3</b>	27.4	43.5	59.0	38.4	31.4	34.8	45.8
SY INGMAR	82.8	34.1	56.9	26.3	44.5	54.6	39.3	32.8	<b>40.1</b>	45.7
<b>Mean (n=32)</b>	<b>87.0</b>	<b>36.0</b>	<b>62.4</b>	<b>30.9</b>	<b>49.3</b>	<b>59.2</b>	<b>43.7</b>	<b>34.7</b>	<b>38.5</b>	<b>49.1</b>
C.V.	5.4	9.3	9.4	14.1	8.2	4.4	7.3	9.3	10.8	6.2
Prob. (line)	<0.001	<0.01	<0.05	<0.05	<0.05	<0.001	<0.001	<0.05	<0.01	<0.001
<b>LSD (0.05)</b>	<b>7.7</b>	<b>5.5</b>	<b>9.6</b>	<b>7.1</b>	<b>8.2</b>	<b>4.2</b>	<b>5.2</b>	<b>5.3</b>	<b>6.8</b>	<b>2.8</b>

Table 2. Grain yield (bu/ac) comparisons between MT2050 and common varieties grown in 34 Advanced Yield Trial (AYT) rain-fed and irrigated location-years from 2021 to 2023. Thirty-two common varieties were grown in all three years and were included in the combined analysis. Bold values indicate varieties were not significantly different from the highest yielding line. Table sorted based on combined means.

Loc.	Bozeman (rainfed)	Have	Huntley/ Billings	Moccasin	Conrad	Sidney (rainfed)	Fort benton	Hingham	Williston	Bozeman (irrigated)	Sidney (irrigated)	Kalispell (high rainfall)	Overall Mean
Year	2021-2023	2021-2023	2021-2023	2021-2023	2021, 2023	2021-2023	2021-2023	2021-2023	2021-2023	2022-2023	2021-2023	2021-2023	N = 34
MT CARLSON	<b>95.5</b>	<b>38.3</b>	<b>68.0</b>	<b>35.3</b>	<b>58.6</b>	<b>64.0</b>	<b>48.8</b>	<b>37.7</b>	<b>42.5</b>	<b>122.3</b>	<b>91.2</b>	<b>108.6</b>	<b>67.6</b>
MT DUTTON	<b>95.4</b>	<b>40.0</b>	<b>67.6</b>	<b>33.1</b>	<b>51.3</b>	<b>65.0</b>	<b>47.3</b>	<b>39.5</b>	<b>45.0</b>	<b>124.0</b>	<b>93.9</b>	<b>101.1</b>	<b>66.9</b>
DAGMAR	<b>91.2</b>	<b>41.6</b>	<b>67.5</b>	<b>36.4</b>	<b>54.6</b>	<b>65.7</b>	<b>45.3</b>	<b>34.6</b>	<b>41.4</b>	<b>119.4</b>	<b>95.6</b>	<b>98.9</b>	<b>66.0</b>
LCS ASCENT	<b>95.2</b>	<b>37.0</b>	<b>62.2</b>	<b>33.5</b>	<b>53.6</b>	<b>64.4</b>	41.1	<b>34.2</b>	<b>43.3</b>	<b>128.5</b>	<b>94.9</b>	<b>99.8</b>	<b>65.6</b>
WB 9516	<b>92.8</b>	<b>37.5</b>	<b>65.7</b>	26.2	<b>55.4</b>	59.9	<b>46.6</b>	<b>34.4</b>	37.2	<b>129.3</b>	<b>97.5</b>	<b>105.0</b>	<b>65.6</b>
MT 2030	<b>96.1</b>	36.0	<b>64.4</b>	<b>35.6</b>	<b>52.8</b>	<b>66.7</b>	<b>48.8</b>	<b>37.4</b>	36.1	<b>119.5</b>	<b>96.3</b>	94.1	<b>65.3</b>
MT 2049	<b>91.2</b>	<b>38.4</b>	<b>63.5</b>	<b>36.7</b>	49.5	<b>62.6</b>	43.9	<b>35.6</b>	<b>41.6</b>	<b>117.3</b>	<b>91.5</b>	<b>99.9</b>	<b>64.3</b>
MT SIDNEY	<b>90.2</b>	33.5	<b>65.3</b>	<b>32.4</b>	50.3	61.9	43.4	<b>33.6</b>	<b>39.7</b>	<b>119.5</b>	<b>93.2</b>	<b>106.4</b>	64.1
VIDA	<b>89.8</b>	<b>38.4</b>	<b>67.0</b>	<b>33.2</b>	47.7	<b>63.2</b>	<b>49.6</b>	<b>38.9</b>	<b>42.4</b>	114.2	<b>93.0</b>	91.1	64.0
ROCKER	<b>92.1</b>	<b>39.2</b>	<b>66.9</b>	<b>32.8</b>	<b>50.8</b>	60.3	<b>49.0</b>	34.0	<b>40.3</b>	114.2	<b>96.8</b>	91.2	64.0
<b>MT 2050</b>	87.6	<b>39.8</b>	<b>63.3</b>	<b>32.9</b>	<b>52.6</b>	60.1	<b>47.1</b>	34.1	36.9	<b>121.5</b>	<b>92.1</b>	<b>96.0</b>	63.7
SY ROCKFORD	<b>91.9</b>	<b>38.6</b>	<b>64.2</b>	<b>32.4</b>	<b>52.2</b>	60.4	37.1	29.4	<b>40.5</b>	<b>118.8</b>	<b>92.3</b>	92.7	62.5
WB 9719	<b>91.7</b>	35.1	<b>58.8</b>	26.6	50.4	59.9	<b>44.8</b>	<b>35.2</b>	<b>38.5</b>	111.1	<b>95.8</b>	<b>96.7</b>	62.1
LANNING	88.3	35.6	<b>62.8</b>	<b>33.0</b>	<b>50.7</b>	<b>62.7</b>	<b>45.8</b>	32.2	<b>40.1</b>	111.8	89.2	90.2	61.9
SY LONGMIRE	85.3	33.1	<b>66.2</b>	24.9	49.1	55.9	<b>44.9</b>	33.9	<b>39.8</b>	<b>114.5</b>	<b>93.8</b>	<b>96.4</b>	61.5
DUCLAIR	<b>90.2</b>	34.3	<b>64.5</b>	<b>30.6</b>	45.2	52.6	44.2	<b>34.4</b>	37.5	<b>117.9</b>	89.7	<b>96.2</b>	61.4
REEDER	86.5	35.5	<b>61.6</b>	29.6	48.9	59.1	41.9	<b>35.5</b>	36.6	104.4	<b>92.0</b>	91.0	60.2
WB GUNNISON	80.2	<b>40.2</b>	58.1	27.4	<b>51.9</b>	54.1	<b>44.7</b>	<b>39.6</b>	<b>38.7</b>	109.4	80.5	<b>96.9</b>	60.1
AP SMITH	83.5	32.8	<b>61.3</b>	27.4	43.5	59.0	38.4	31.4	34.8	108.3	89.2	94.4	58.7
SY INGMAR	82.8	34.1	56.9	26.3	44.5	54.6	39.3	32.8	<b>40.1</b>	107.4	86.2	87.8	57.7
CORBIN	78.3	35.7	57.0	27.6	<b>52.3</b>	52.9	42.1	<b>36.6</b>	36.6	99.8	79.0	94.5	57.7
<b>Mean (n=32)</b>	<b>87.0</b>	<b>36.0</b>	<b>62.4</b>	<b>30.9</b>	<b>49.3</b>	<b>59.2</b>	<b>43.7</b>	<b>34.7</b>	<b>38.5</b>	<b>113.8</b>	<b>90.4</b>	<b>95.3</b>	<b>61.7</b>
C.V.	5.4	9.3	9.4	14.1	8.2	4.4	7.3	9.3	10.8	6.5	5.3	8.3	6.3
Prob. (line)	<0.001	<0.01	<0.05	<0.05	<0.05	<0.001	<0.001	<0.05	<0.01	<0.001	<0.001	<0.05	<0.001
<b>LSD (0.05)</b>	<b>7.7</b>	<b>5.5</b>	<b>9.6</b>	<b>7.1</b>	<b>8.2</b>	<b>4.2</b>	<b>5.2</b>	<b>5.3</b>	<b>6.8</b>	<b>15.1</b>	<b>7.8</b>	<b>13.0</b>	<b>3.1</b>

Table 3. Grain protein content (%) comparisons between MT2050 and check varieties grown in 34 Advanced Yield Trial (AYT) rain-fed and irrigated location-years from 2021 to 2023. Thirty-two common varieties were grown in all three years and were included in the combined analysis. Bold values indicate varieties were not significantly different from the highest grain protein content value. Table sorted based on combined means.

Loc. Year	Bozeman (rainfed) 2021-2023	Havre 2021-2023	Huntley/ Billings 2021-2023	Moccasin 2021-2023	Conrad 2021, 2023	Sidney (rainfed) 2021-2023	Fort Benton 2021-2023	Hingham 2021-2023	Williston 2021-2023	Bozeman (irrigated) 2022-2023	Sidney (irrigated) 2021-2023	Kalispell (high rainfall) 2021-2023	Overall Mean
SY INGMAR	<b>15.4</b>	<b>16.3</b>	<b>15.4</b>	<b>17.6</b>	14.5	<b>14.2</b>	15.7	14.2	15.3	14.9	14.4	12.1	<b>15.0</b>
AP SMITH	<b>15.3</b>	<b>16.4</b>	<b>15.2</b>	<b>17.1</b>	14.6	<b>14.3</b>	15.6	<b>14.3</b>	<b>15.7</b>	14.9	14.2	<b>12.3</b>	<b>15.0</b>
LANNING	<b>15.5</b>	<b>16.2</b>	<b>15.4</b>	15.9	13.6	<b>14.1</b>	16.0	<b>14.3</b>	15.4	15.1	<b>14.8</b>	11.7	<b>14.8</b>
DAGMAR	<b>15.4</b>	<b>16.0</b>	<b>15.1</b>	15.7	14.4	<b>14.1</b>	15.4	14.2	15.1	15.3	<b>15.0</b>	11.5	<b>14.8</b>
SY LONGMIRE	14.8	<b>16.7</b>	<b>14.9</b>	<b>17.4</b>	13.5	13.8	15.5	14.1	<b>15.6</b>	14.5	14.1	11.2	<b>14.7</b>
REEDER	15.0	<b>16.0</b>	14.7	16.3	13.8	<b>13.9</b>	15.5	13.6	15.4	15.2	14.2	11.7	14.6
CORBIN	14.5	<b>16.7</b>	14.3	<b>16.9</b>	13.7	13.8	14.9	14.0	<b>15.8</b>	14.6	14.4	10.9	14.5
DUCLAIR	14.6	<b>16.6</b>	14.3	16.4	14.2	13.6	14.8	14.0	<b>16.1</b>	14.3	14.0	11.1	14.5
MT 2049	14.7	15.4	<b>14.9</b>	15.3	14.1	13.5	15.0	14.2	15.1	14.9	14.5	11.9	14.5
MT DUTTON	15.0	15.9	14.8	15.8	13.2	13.6	15.1	13.9	15.4	15.3	14.1	11.0	14.4
ROCKER	15.0	<b>16.3</b>	14.4	15.9	13.5	<b>13.9</b>	15.0	13.0	<b>15.5</b>	14.8	13.8	11.2	14.4
MT 2030	15.1	15.6	14.7	15.5	13.7	12.9	15.1	13.6	15.0	15.3	14.3	11.4	14.4
MT SIDNEY	14.7	<b>16.1</b>	14.1	15.9	13.9	13.5	15.3	13.8	15.1	14.5	13.9	11.2	14.3
<b>MT 2050</b>	14.3	15.3	14.3	15.7	13.7	13.4	14.8	13.7	15.2	14.6	14.5	11.5	14.3
MT CARLSON	14.6	15.7	14.3	15.5	13.8	13.3	15.0	13.2	15.2	14.6	13.9	11.2	14.2
SY ROCKFORD	14.1	<b>16.0</b>	14.5	15.9	13.7	13.4	15.1	13.8	14.8	13.8	13.8	11.4	14.2
WB 9719	14.4	15.8	14.3	16.5	12.8	13.5	14.9	13.2	15.0	13.9	13.8	11.1	14.1
VIDA	14.4	15.6	14.3	15.8	13.8	12.9	14.6	13.1	15.2	14.6	13.7	10.9	14.1
WB 9516	13.9	15.3	14.1	<b>16.8</b>	13.0	13.1	14.2	13.4	14.6	13.7	13.4	11.4	13.9
LCS ASCENT	14.4	15.1	14.2	15.4	13.8	13.1	14.1	13.0	14.8	14.0	13.6	11.0	13.9
WB GUNNISON	14.1	15.0	14.1	16.1	13.1	13.3	14.5	13.0	15.0	13.8	13.5	10.9	13.9
<b>Mean (n=32)</b>	<b>14.8</b>	<b>16.0</b>	<b>14.6</b>	<b>16.2</b>	<b>13.8</b>	<b>13.7</b>	<b>15.1</b>	<b>13.7</b>	<b>15.4</b>	<b>14.7</b>	<b>14.1</b>	<b>11.3</b>	<b>14.5</b>
C.V.	2.5	3.3	3.5	4.2	3.9	3.3	2.3	4.5	3.6	2.1	3.1	5.2	2.5
Prob. (line)	<0.001	<0.01	<0.01	<0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001
<b>LSD (0.05)</b>	<b>0.6</b>	<b>0.8</b>	<b>0.8</b>	<b>1.1</b>	-	<b>0.7</b>	<b>0.6</b>	<b>1.0</b>	<b>0.9</b>	<b>0.6</b>	<b>0.7</b>	-	<b>0.3</b>

Table 4. Agronomic trait comparisons between MT2050 and common varieties collected from a maximum of 32 Advanced Yield Trial (AYT) rain-fed and irrigated location-years from 2021 to 2023. Thirty-two common varieties were grown in all three years and were included in the combined analysis. Bold values indicate varieties were not significantly different from the optimum value. After MT2050, the table was sorted alphabetically based on variety name.

Traits	Test weight (lb/bu)	Heading date (Julian Days)	Maturity date (Julian Days)	Plant height (inch)	Stem solidness (5-25)	Sawfly cutting (%)	Sawfly cutting (%)	Aluminum Tolerance
Environments	32	22	7	30	Bozeman (21-23)	Fort Benton (21-22)	Havre (21-22)	Rockford, WA (21-22)
<b>MT 2050</b>	59.7	176.7	207.9	29.1	19.0	<b>24.2</b>	<b>12.5</b>	S
AP SMITH	60.2	178.1	208.0	26.1	10.2	67.6	41.2	S
CORBIN	60.1	175.3	<b>206.7</b>	29.1	12.6	<b>24.7</b>	<b>6.5</b>	T
DAGMAR	60.7	174.9	207.3	30.0	17.4	<b>23.9</b>	<b>2.7</b>	S
DUCLAIR	59.2	175.1	<b>205.4</b>	29.3	19.3	<b>19.8</b>	<b>3.9</b>	T
LANNING	59.7	175.9	<b>206.6</b>	28.3	7.7	74.3	51.0	T
LCS ASCENT	61.4	<b>174.4</b>	208.4	29.2	6.8	64.0	39.4	MT
MT 2030	60.1	176.1	207.2	28.5	12.8	75.3	47.5	MS
MT 2049	59.6	<b>174.3</b>	<b>206.4</b>	27.9	11.0	65.9	43.0	MT
MT CARLSON	60.0	176.0	<b>206.2</b>	28.7	18.1	<b>26.4</b>	27.0	T
MT DUTTON	59.4	176.9	208.6	29.5	11.0	36.9	23.2	MT
MT SIDNEY	60.3	175.7	208.7	29.5	9.3	68.6	<b>18.1</b>	S
REEDER	60.1	177.3	210.2	30.6	7.2	56.6	42.9	T
ROCKER	60.8	178.1	208.4	29.3	10.3	<b>23.9</b>	<b>11.5</b>	S
SY INGMAR	60.5	177.9	207.7	27.7	8.8	61.1	36.9	S
SY LONGMIRE	60.6	176.7	<b>206.6</b>	28.1	<b>20.6</b>	<b>27.2</b>	<b>14.0</b>	T
SY ROCKFORD	59.1	178.8	207.5	29.1	7.9	74.4	48.0	T
VIDA	59.7	177.6	209.7	29.7	12.8	<b>26.7</b>	<b>14.6</b>	S
WB 9516	61.3	177.3	210.6	28.6	8.1	47.1	26.4	N/A
WB 9719	<b>62.1</b>	178.1	209.5	27.5	6.6	61.4	50.7	N/A
WB GUNNISON	60.5	177.1	208.8	27.7	11.4	<b>22.1</b>	<b>3.4</b>	S
<b>Mean (n=32)</b>	<b>60.0</b>	<b>177.0</b>	<b>207.9</b>	<b>29.3</b>	<b>11.9</b>	<b>48.1</b>	<b>26.8</b>	
C.V.	1.1	0.4	0.7	3.2	11.2	23.8	33.3	
Prob. (line)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
<b>LSD (0.05)</b>	<b>0.5</b>	<b>0.6</b>	<b>1.5</b>	<b>0.8</b>	<b>2.2</b>	<b>23.4</b>	<b>18.2</b>	



Table 5. Yield and agronomic data were collected from 28 Spring Wheat Off-Station Yield Trial locations from 2022 to 2023. Varieties were grown in 21 rainfed and 7 irrigated environments. Seventeen common varieties were grown both years and were included in the analysis. Underlined values indicate values not significantly different from the optimum value. The table was sorted based on combined yield means.

No. of environments	Yield (bu/ac)			Test Weight (lb/bu)			Grain Protein (%)			Heading Date (Julian Days)			Plant Height (Inches)			Sawfly Cutting (%)	Falling Number (seconds)		
	21	7	28	21	7	28	21	7	28	3	2	5	21	7	28	7	8	1	9
Line/Variety	RAINFED	IRRI	TOTAL	RAINFED	IRRI	TOTAL	RAINFED	IRRI	TOTAL	RAINFED	IRRI	TOTAL	RAINFED	IRRI	TOTAL	TOTAL	RAINFED	IRRI	TOTAL
MT CARLSON	<u>46.2</u>	101.0	<u>59.9</u>	59.8	<b>59.8</b>	59.8	14.1	14.2	14.2	168.5	165.7	167.4	27.1	34.3	28.9	<b>12.7</b>	418	375	413
MT 2030	<b>45.5</b>	<u>101.7</u>	<b>59.6</b>	59.9	<b>59.8</b>	59.9	14.1	14.6	14.2	168.0	167.4	167.7	27.3	34.7	29.2	<b>27.5</b>	441	<b>409</b>	<b>437</b>
DAGMAR	<b>45.0</b>	<u>101.7</u>	<b>59.1</b>	60.5	<b>59.7</b>	60.3	14.6	14.8	14.7	<b>166.5</b>	<u>163.5</u>	<u>165.3</u>	<b>28.5</b>	35.4	30.2	<b>12.6</b>	432	363	424
MT DUTTON	<b>44.2</b>	99.5	<b>58.0</b>	59.0	59.2	59.1	14.6	14.5	14.6	168.6	166.9	167.9	27.8	35.3	29.7	<b>25.2</b>	432	348	423
VIDA	43.5	97.2	<b>57.0</b>	59.6	59.0	59.4	14.1	14.4	14.2	169.9	167.3	168.9	<b>28.3</b>	35.5	30.1	<b>19.7</b>	405	348	398
MT 2049	<b>44.0</b>	95.7	<b>56.9</b>	59.8	<b>59.6</b>	59.8	14.0	14.6	14.2	<u>166.0</u>	<b>164.5</b>	<b>165.4</b>	27.5	33.3	28.9	34.1	424	355	416
MT SIDNEY	43.2	97.7	<b>56.9</b>	60.4	<b>60.1</b>	60.3	14.2	14.3	14.3	168.1	165.8	167.2	27.9	34.3	29.5	28.6	421	357	414
<b>MT 2050</b>	42.7	99.2	<b>56.8</b>	59.6	<b>59.6</b>	59.6	14.1	14.2	14.1	168.9	166.6	168.0	27.5	35.4	29.5	<b>14.0</b>	413	379	409
LANNING	43.0	94.3	<b>55.8</b>	59.0	<b>59.5</b>	59.1	14.8	14.8	<b>14.8</b>	<b>166.8</b>	166.4	166.6	27.4	33.9	29.0	30.8	407	357	402
DUCLAIR	41.4	96.1	55.1	59.0	59.0	59.0	14.6	14.6	14.6	168.2	165.9	167.3	28.0	35.0	29.7	<b>12.3</b>	397	357	392
WB9879CLP	41.6	94.9	54.9	59.6	<b>59.6</b>	59.6	14.7	14.6	14.7	170.5	167.7	169.4	27.1	34.9	29.1	<u>5.6</u>	430	385	425
REEDER	40.6	95.5	54.3	59.9	<b>59.9</b>	59.9	14.6	<b>14.9</b>	14.7	168.5	167.1	167.9	<b>28.8</b>	<b>38.7</b>	<b>31.3</b>	31.8	410	358	405
SY INGMAR	39.3	96.3	53.5	60.1	<b>60.4</b>	60.1	<b>15.0</b>	14.7	<b>14.9</b>	169.9	168.3	169.2	26.7	33.4	28.3	28.5	<b>467</b>	354	<b>455</b>
SY SOREN	40.3	91.9	53.2	59.9	<b>60.3</b>	60.0	<u>15.1</u>	14.6	<b>15.0</b>	169.1	166.3	168.0	26.4	32.8	28.0	<b>25.8</b>	<b>459</b>	359	<b>448</b>
BRENNAN	40.1	91.9	53.1	<b>61.3</b>	<b>60.2</b>	<b>61.0</b>	14.9	14.7	<b>14.9</b>	<b>167.5</b>	165.6	166.7	26.0	31.9	27.5	<b>27.6</b>	<b>452</b>	376	<b>444</b>
<b>Mean (n=17)</b>	<b>42.7</b>	<b>96.6</b>	<b>56.2</b>	<b>59.8</b>	<b>59.6</b>	<b>59.7</b>	<b>14.5</b>	<b>14.5</b>	<b>14.5</b>	<b>168.5</b>	<b>166.5</b>	<b>167.7</b>	<b>27.6</b>	<b>34.7</b>	<b>29.3</b>	<b>22.5</b>	<b>424</b>	<b>364</b>	<b>417</b>
C.V.	9.3	8.2	14.8	1.3	1.9	1.8	2.8	4.1	4.6	0.6	0.5	0.6	4.1	3.9	5.5	49.1	4.1	-	5.2
Prob. (line)	<0.001	ns	<0.05	<0.001	<0.05	<0.001	<0.001	ns	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001
<b>LSD (0.05)</b>	<b>2.4</b>	-	<b>4.4</b>	<b>0.5</b>	<b>1.2</b>	<b>0.6</b>	<b>0.2</b>	-	<b>0.3</b>	<b>1.6</b>	<b>1.9</b>	<b>1.2</b>	<b>0.7</b>	<b>1.4</b>	<b>0.8</b>	<b>11.7</b>	<b>17</b>	-	<b>20</b>

Table 6. 2021 Fungal leaf spot evaluation of MT2050 compared to other regionally adapted varieties (Dr. Zhaohui Liu, NDSU, Fargo, ND).

Line	Ptr ToxA <sup>1</sup>	Ptr Race 1 <sup>2</sup>	Ptr Race 5 <sup>2</sup>	Sn4 <sup>3</sup>
<b>MT 2050</b>	0	3.5	2	3
MT 2030	0	4	4	2
MT 2049	1	3.5	3.5	1.5
BRENNAN	0	2.5	2	2.5
CHOTEAU	0	2.5	3.5	0.5
CORBIN	1	4.5	3	4.5
DAGMAR	0	2	4	0.5
DUCLAIR	0	3.5	3.5	0.5
LANNING	0	1.5	4	2
MCNEAL	0	1	1	1
MT CARLSON	0	3.5	3.5	0.5
MT DUTTON	0	2	2	2.5
MT SIDNEY	0	2	4	0.5
REEDER	1	2	4.5	3.5
SY INGMAR	1	3.5	3.5	3
SY ROCKFORD	0	1.5	1	3.5
SY SOREN	0	2	1	2.5
VIDA	0	2	1	2
WB GUNNISON	1	3.5	2.5	3.5
Salamouni (check)	0	1.5	1	1
Glenelea (check)	1	4	2.5	4

<sup>1</sup>*P. tritici-repentis* (Ptr) ToxA: 0=insensitive; 1=sensitive, ND=no data. ToxA sensitivity is conferred by *Tsn1*.

<sup>2</sup>Evaluation with Ptr races 1 (predominant in North Dakota) and 5 using a 0-5 scale, 1,2=resistant, 3=moderately susceptible, 4, 5=highly susceptible, ND=no data.

<sup>3</sup>Evaluation with *Septoria nodorum* isolate Sn4 (predominant in North Dakota) using 0-5 scale, 0-2=resistant, 3=moderately susceptible, 4,5=highly susceptible.

**Table 7. Fusarium head blight (FHB) resistance of MT2050 compared to other regionally adapted control varieties evaluated in Sidney, MT from 2021 to 2023. Table sorted based on DON values. (Dr. Frankie Crutcher, MSU-EARC, Sidney, MT)**

Variety	% Severity <sup>a</sup>	% Incidence <sup>b</sup>	Disease Index <sup>c</sup>	% FDK <sup>d</sup>	DON (ppm)
<b>2021</b>					
MT 2030	11.8 B-D	46.7 A-D	5.5 C	0 B	0.2
Vida	12.9 B-D	46.7 B-D	6.1 C	0.3 B	0.2
MT Dutton	4.8 CD	26.7 D	2.2 C	0.5 B	0.3
Lanning	8.3 B-D	46.7 B-D	4.0 C	1.3 B	0.3
<b>MT 2050</b>	<b>28.2 A</b>	<b>65.6 AB</b>	<b>18.4 AB</b>	<b>0.3 B</b>	<b>0.4</b>
MT Sidney	11.8 B-D	45.6 B-D	5.5 C	3.3 B	0.4
Ingmar	2.9 D	31.7 CD	0.9 C	0.5 B	0.5
Dagmar	13.7 B-D	55.6 A-D	7.6 C	1.7 B	0.7
Reeder	15.5 BC	53.3 A-D	8.2 C	1.7 B	1.1
MT 2049	10.3 B-D	51.1 A-D	5.2 C	1.7 B	1.2
MT Carlson	18.6 AB	56.7 A-D	10.9 BC	1.0 B	1.6
McNeal	30.0 A	75.6 A	22.9 A	11.7 A	2.5
<b>Mean</b>	<b>14.7</b>	<b>52</b>	<b>8.6</b>	<b>2.2</b>	<b>0.8</b>
<b>P value</b>	<b>&lt;0.0001</b>	<b>0.001</b>	<b>&lt;0.0001</b>	<b>&lt;0.0001</b>	<b>0.068</b>
<b>HSD (0.05)</b>	<b>10.4</b>	<b>28.5</b>	<b>9.6</b>	<b>5.9</b>	<b>n/a</b>
<b>2022</b>					
MT Sidney	28.1 C	90	25.2 C	48.3	7.3 B
MT Dutton	33.0 BC	94.4	31.3 BC	33.3	10.6 B
MT 2049	41.3 A-C	91.1	39.1 A-C	48.3	13.9 AB
Ingmar	34.8 BC	91.1	31.9 BC	38.3	15.4 AB
Dagmar	42.3 A-C	96.7	40.9 A-C	37.5	17.1 AB
Reeder	48.8 A-C	100	48.8 A-C	48.3	18.6 AB
Vida	42.2 A-C	94.4	40.3 A-C	45	19.2 AB
MT 2030	43.0 A-C	96.7	41.7 A-C	51.7	19.7 AB
McNeal	68.1 A	97.8	66.6 A	60	28.8 AB
MT Carlson	58.2 AB	100	58.2 AB	60	36.3 AB
Lanning	44.7 A-C	100	44.7 A-C	45	38.8 AB
<b>MT 2050</b>	<b>57.2 A-C</b>	<b>98.9</b>	<b>56.6 A-C</b>	<b>63.3</b>	<b>43.4 A</b>
<b>Mean</b>	<b>45.8</b>	<b>96</b>	<b>44.4</b>	<b>49.1</b>	<b>23.1</b>
<b>P value</b>	<b>0.0027</b>	<b>0.3411</b>	<b>0.0038</b>	<b>0.2914</b>	<b>0.0039</b>
<b>HSD (0.05)</b>	<b>29.5</b>	<b>n/a</b>	<b>32.2</b>	<b>n/a</b>	<b>31.1</b>
<b>2023</b>					
MT Sidney	19.3	70.0 CD	15.1 C	14.7 C	3.0 E
Ingmar	9.4	61.7 D	6.1 C	14.0 C	3.0 E
MT Dutton	23.4	77.8 CD	18.8 C	18.3 BC	4.4 DE
Vida	27.7	84.4 CD	23.5 BC	33.3 A-C	8.0 C-E
MT 2030	24.8	81.1 CD	21.0 C	14.3 C	8.1 C-E
Lanning	17.8	64.4 CD	11.5 C	25.0 A-C	8.3 C-E
Reeder	18.3	64.4 CD	14.2 C	31.7 A-C	8.3 C-E
MT 2049	30.3	68.9 B-D	22.4 C	30.0 A-C	9.0 C-E
<b>MT 2050</b>	<b>43.7</b>	<b>84.4 A-C</b>	<b>38.0 A-C</b>	<b>33.3 A-C</b>	<b>11.0 CD</b>
Dagmar	43.9	92.2 A-C	40.7 A-C	35.0 A-C	12.0 C
McNeal	60.5	98.9 A	59.8 A	36.7 A-C	19.4 AB
MT Carlson	58.1	95.6 AB	55.9 AB	45.0 A	23.0 A
<b>Mean</b>	<b>52.5</b>	<b>79.6</b>	<b>65.4</b>	<b>29.1</b>	<b>10.2</b>
<b>P value</b>	<b>&lt;0.0001</b>	<b>0.1078</b>	<b>&lt;0.0001</b>	<b>0.0012</b>	<b>&lt;0.0001</b>
<b>HSD (0.05)</b>	<b>28.6</b>	<b>n/a</b>	<b>33.2</b>	<b>25.7</b>	<b>6.9</b>

Letters in common were not statistically different according to a Tukey's HSD test ( $P < 0.05$ ).

<sup>a</sup>Severity: Average percent area of head covered by disease. Thirty heads were evaluated for each plot.

<sup>b</sup>Incidence: Percent of thirty plants per plot that had visible FHB symptoms.

<sup>c</sup>Disease Index is calculated as (Severity X Incidence)/100

<sup>d</sup>Fusarium damaged kernels

Table 8. 2023 Western Regional spring wheat stripe rust evaluation under natural infection. (Dr. Xianming Chen, USDA-ARS, Pullman, WA).

Observation Date Growth Stage Name	Spillman, WA				Polouse, WA		Mount Vernon, WA				Summary <sup>c</sup>	Overall rating <sup>d</sup>
	7/3		7/12		7/3		6/7		6/27			
	Fks 11.1	Fks 11.2	Fks 11.1	Fks 11.2	Fks 11.1	Fks 11.2	Fks 4	Fks 10.54	Fks 4	Fks 10.54		
IT	%	IT	%	IT	%	IT	%	IT	%			
<b>MT2050</b>	2	5	3	10	2	20	3	40	5	40	MR	4
MT2030	2	5	2	5	8	90	8	80	8	90	S	9
MT2049	2	5	8	20	8	50	8	80	8	90	S	9
Glee	2	5	2	5	3	30	3	50	2	20	R	3
Jefferson	2	5	2	5	2	20	3	30	2	20	R	2
UI Platinum	2	5	2	5	5	40	5	30	2	20	MR	4
Dagmar	2	5	8	20	5	50	5	50	3	30	MR	5
IDO2002S	2	5	2	5	3	30	3	20	2	15	R	3
IDO2202CL2	2	5	2	5	8	60	2	30	8	40	MS	7
IDO2104HF	2	5	5	10	3	30	3	30	2	20	R	3
IDO2105S	2	5	2	5	3	30	3	30	3	30	R	3
MT2063	2	5	8	10	3	30	5	50	3	30	MR	4
AVS (S. check)	9	20	9	80	9	100	9	80	9	100	S	9

<sup>a</sup> Infection Type (IT) was recorded based on the 0-9 scale with ITs 8 and 9 combined as 8 (the most susceptible reaction) in field data. Generally IT 0-3 are considered resistant, 4-6 intermediate, and 7-9 susceptible. Heterogenous reactions of an entry were indicated by two or more ITs separated by "," for most plants with the first IT and few plants with the second IT or connected with "-" for entries containing plants with continuous ITs.

<sup>b</sup> Entries with a high IT in the first note, but a low IT in the second note at Mt. Vernon may indicate the lines have high-temperature, adult-plant (HTAP) resistance.

<sup>c</sup> R = resistant, MR = moderately resistant, MS = moderately susceptible, and S = susceptible.

<sup>d</sup> 1 = most resistant and 9 most susceptible.

Table 9. End-Use quality combined analysis of eight Advanced Yield Trial (AYT) location-years from 2021 to 2023. End-Use quality samples were from Bozeman, MT (2021-2023), Havre, MT (2022-2023), and Sidney, MT (2021- 2023). Thirty-two entries were common in all locations and used in the combined analysis. Bold values indicate lines that were not significantly different from the optimum value. The table is sorted based on mixing tolerance.

Variety/Line	Flour yield (%)	Flour protein (% (%, 14% m.b.)	Mixing tolerance	Mixing time (min.)	Mixing water absorption (%)	Bake mix time (min.)	Bake water absorption (%)	Loaf volume (cc)
WB 9719	70.2	13.5	<b>3.9</b>	5.6	<b>69.7</b>	13.3	79.3	1067
WB GUNNISON	68.0	12.6	<b>3.8</b>	<b>7.6</b>	67.1	<b>15.4</b>	78.2	1133
MCNEAL	68.4	13.7	<b>3.6</b>	<b>7.2</b>	<b>70.6</b>	14.2	<b>80.0</b>	<b>1190</b>
SY Longmire	69.9	13.7	<b>3.6</b>	5.3	<b>69.5</b>	11.7	<b>79.5</b>	<b>1187</b>
AP Smith	70.1	<b>14.0</b>	<b>3.5</b>	<b>7.4</b>	<b>71.6</b>	<b>17.9</b>	<b>81.8</b>	1079
ROCKER	69.1	<b>13.9</b>	<b>3.5</b>	6.3	<b>70.1</b>	13.1	<b>80.4</b>	<b>1198</b>
DAGMAR	70.0	13.6	3.4	4.1	68.8	8.5	78.3	1118
DUCLAIR	69.8	13.6	3.4	4.6	68.4	10.3	77.8	<b>1163</b>
SY INGMAR	70.5	<b>14.3</b>	3.4	6.0	<b>71.1</b>	14.6	<b>80.2</b>	<b>1207</b>
LCS ASCENT	70.6	12.9	3.1	4.8	68.6	10.0	77.7	1106
SY Rockford	70.4	12.9	3.0	4.5	67.9	10.0	77.5	1109
LANNING	70.2	<b>14.0</b>	2.8	4.0	68.7	9.4	78.6	<b>1171</b>
MT CARLSON	68.9	13.4	2.8	3.6	67.7	8.1	77.2	1128
MT 2030	<b>71.4</b>	13.4	2.6	4.0	67.7	9.0	77.1	1081
WB 9516	70.2	12.8	2.6	4.8	66.3	10.3	75.4	1054
MT 2049	<b>71.7</b>	13.5	2.3	4.2	68.1	11.2	77.3	1116
<b>MT 2050</b>	69.4	13.0	2.3	3.0	65.9	5.4	74.8	1008
MT DUTTON	70.6	13.1	2.1	2.9	67.7	5.5	76.7	1121
CORBIN	70.3	13.4	2.0	5.9	68.2	13.5	77.2	1043
MT SIDNEY	70.8	13.5	1.9	4.1	66.9	10.6	76.5	1124
REEDER	68.8	13.7	1.9	3.3	67.5	6.7	76.5	1134
VIDA	<b>71.7</b>	12.9	1.5	3.5	67.2	7.9	76.6	1133
<b>MEAN (n=32)</b>	<b>69.9</b>	<b>13.5</b>	<b>2.9</b>	<b>4.7</b>	<b>68.4</b>	<b>10.3</b>	<b>77.9</b>	<b>1117</b>
CV	1.6	4.7	25.3	27.4	3.2	26.9	3.2	6.2
PAROBA	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>LSD</b>	<b>1.1</b>	<b>0.6</b>	<b>0.7</b>	<b>1.3</b>	<b>2.2</b>	<b>2.7</b>	<b>2.4</b>	<b>69</b>