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**MEMORANDUM**

**TO:** Wheat Variety Release Committee

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

**DATE:** January 25th, 2023

**RE:** Proposal for protected MAES public cultivar release of MT1939

The following motion and supporting documentation are presented for consideration at the 2023 MAES Variety Release Meeting in Bozeman, MT:

**Motion:** Release MT1939 hard red spring wheat as an AOSCA registered public variety with PVP Title V protection.

**Pedigree:** Lanning/MT1531

**CONTRIBUTORS**

- Dr. Jason Cook, Ms. Nancy Blake, Ms. Deanna Nash, Dr. Hwa-Young Heo, MSU Bozeman, MT
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- Ms. Peggy Lamb MSU-NARC, Havre,
- Dr. Ken Kephart and Dr. Kent McVay, MSU-SARC, Huntley, MT
- Dr. Justin Vetch MSU-WTARC, Conrad, MT
- Dr. Jessica Torrion and Dr. Clint Bierman 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

The rationale for releasing MT1939 is based on it's high yield potential in Montana rainfed environments, moderate wheat stem sawfly resistance, tolerance to aluminum, and good end-use quality. MT1939 was derived from the cross 'Lanning' (Heo et al., 2016)/ MT1531. Lanning was released by the Montana Agriculture Experiment Station (MAES) in 2016 as having high yield in rainfed conditions, good grain protein content and excellent end-use quality. MT1531 was derived from the cross MT1018/CHSY-26. MT1018 was an experimental line derived from the cross 'Choteau' (Lanning et al., 2004)/MT0564. Choteau was released by MAES in 2003 for having very solid stems, good straw strength and good yield compared to other solid stem spring wheat varieties. CHSY-26 is a recombinant inbred line (RIL) selected from a genetic mapping population developed from the cross Choteau/'S-Yellowstone' (Blake et al., 2011) 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 study winter wheat yield component alleles in spring wheat by backcrossing the *Vrn-A1* spring growth habit allele into the winter wheat variety 'Yellowstone' (Bruckner et al., 2007). Yellowstone was released by the MAES in 2005 for having high yield potential and broad adaptation to Montana's winter wheat growing environments and has been one of the most widely grown winter wheat varieties in Montana over the past several years.

Yield and other agronomic measurements were collected from the Advanced Yield Trial (AYT) during the 2020 – 2022 growing seasons totaling 30 location-years including 24 rainfed and 6 irrigated growing environments. Average yield performance of MT1939 across rainfed environments was 1.6 bu/ac higher than 'Vida' (Lanning et al., 2006) (Table 1). Vida is currently the most widely grown spring wheat variety in Montana. Across all location-years, MT1939 yielded 2.8 bu/ac more than Vida and was the top yielding line in the AYT across all environments (Table 2). MT1939 grain protein content is similar to Vida, and 0.8% lower than Lanning (Table 3). Test weight was 60.3 lbs/bu across all environments and heading date was 1.9 days earlier than Vida (Table 4). Solid-stem scores for MT1939, Vida and Dagmar (Heo et al., 2020) were 20.4, 13.4, and 19.4, respectively. Sawfly cutting data collected from Fort Benton, MT was 26.4%, 26.7% and 23.9% for MT1939, Dagmar and Vida, respectively (Table 4). Sawfly cutting at Havre, MT for MT1939, Vida and Dagmar were 27%, 14.6% and 2.7%, respectively. Like Lanning, MT1939 is tolerant to plant available aluminum, (Table 4). Both Vida and Dagmar are susceptible to aluminum.

Data collected from 29 Off-Station Yield Trials consisting of 22 rainfed and 7 irrigated growing environments during the 2021-2022 growing season allowed for additional comparisons between MT1939 and commonly grown varieties in Montana (Table 5). Averaged across rainfed and all environments, MT1939 was the top yielding variety. Sawfly cutting was

analyzed from seven locations where MT1939 had 14.2% cutting verses Vida and Dagmar that were cut 18.2% and 9.8%, respectively.

MT1939 was evaluated in several disease screening nurseries for disease ratings. MT1939 is susceptible to prevalent races of *P. tritici-repentis* but was resistant to the predominant North Dakota *Septoria nodorum* isolate (Table 6). MT1939 is susceptible to Fusarium Head Blight (Table 7) and stripe rust (Table 8) but is resistant to common races of stem rust (Table 9).

End-use quality was tested in six AYT locations grown in 2020 - 2021. Among the 13 lines evaluated, MT1939 had a similar mixing tolerance and bake water absorption to Dagmar, which is considered to have excellent end-use quality for spring wheat (Table 10). Compared to Vida, MT1939's end-use quality is superior. Overall, we conclude MT1939 has good end-use quality.

**References:**


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Table 1. Grain yield (bu/ac) comparisons between MT1939 and check varieties grown in 24 Advanced Yield Trial (AYT) **rainfed** location-years from 2020 to 2022. Twenty common varieties were grown in all three years and were incluced in the combined analysis. Underlined values indicate varieties were not significantly different from the highest yielding line. Table sorted based on combined means.

| Loc. | Bozeman (rain-fed) | Conrad | Fort Benton | Havre | Hingham/ Rudyard | Huntley/ Billings | Moccasin | Sidney (rain-fed) | Williston | Combined Loc/Yr |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2020-2022 | 2021 | 2020-2022 | 2020-2022 | 2021-2022/ 2021 | 2020-2021/ 2022 | 2020-2022 | 2020-2022 | 2021-2022 | N = 24 |
| **MT 1939** | **84.7** | **54.1** | **43.3** | **43.9** | **27.6** | **68.1** | **38.0** | **50.1** | **39.9** | **50.2** |
| MT 1809 | 86.1 | 42.8 | 41.2 | 47.9 | 29.8 | 66.0 | 37.2 | 50.2 | 41.5 | 50.1 |
| NS PRESSER CLP | 79.9 | 50.2 | 39.2 | 41.1 | 29.8 | 66.7 | 37.2 | 51.2 | 41.3 | 48.6 |
| VIDA | 82.8 | 44.6 | 38.7 | 44.1 | 27.8 | 65.9 | 37.3 | 49.7 | 41.0 | 48.6 |
| DAGMAR | 81.9 | 48.2 | 38.5 | 46.6 | 26.7 | 63.1 | 38.5 | 50.1 | 38.3 | 48.4 |
| MT SIDNEY | 77.0 | 46.5 | 34.9 | 40.9 | 26.9 | 65.0 | 34.9 | 46.8 | 39.2 | 46.0 |
| WB 9719 | 80.8 | 45.1 | 39.8 | 40.6 | 27.2 | 62.3 | 29.4 | 45.9 | 37.1 | 45.7 |
| MS RANCHERO | 83.2 | 48.9 | 34.5 | 39.7 | 27.3 | 58.8 | 36.6 | 42.4 | 35.7 | 45.4 |
| SY ROCKFORD | 83.7 | 46.9 | 30.8 | 40.9 | 20.8 | 61.8 | 35.3 | 45.4 | 40.5 | 45.2 |
| WB 9879 CLP | 73.7 | 50.1 | 40.6 | 42.1 | 24.9 | 62.0 | 33.8 | 42.1 | 38.0 | 45.1 |
| LANNING | 77.8 | 46.4 | 36.6 | 40.3 | 24.1 | 59.0 | 37.3 | 45.2 | 38.0 | 45.1 |
| DUCLAIR | 76.1 | 38.7 | 41.8 | 41.7 | 22.8 | 65.2 | 34.0 | 39.2 | 35.4 | 44.7 |
| CHOTEAU | 74.5 | 43.6 | 39.7 | 42.4 | 22.6 | 62.2 | 31.7 | 43.6 | 36.6 | 44.5 |
| REEDER | 73.4 | 47.7 | 35.4 | 40.6 | 25.5 | 59.0 | 33.6 | 47.1 | 37.8 | 44.4 |
| WB GUNNISON | 71.4 | 46.0 | 37.9 | 42.2 | 27.9 | 60.3 | 34.1 | 39.9 | 35.4 | 44.1 |
| SY LONGMIRE | 71.2 | 43.6 | 39.2 | 41.5 | 22.7 | 63.2 | 28.9 | 42.2 | 41.1 | 43.9 |
| MCNEAL | 67.8 | 35.6 | 37.4 | 38.4 | 24.8 | 60.7 | 35.8 | 41.7 | 37.2 | 43.0 |
| CORBIN | 72.5 | 46.4 | 34.6 | 40.9 | 25.3 | 59.1 | 30.8 | 39.5 | 35.0 | 42.7 |
| SY INGMAR | 76.3 | 41.7 | 29.7 | 39.6 | 21.8 | 59.4 | 27.0 | 46.0 | 40.8 | 42.5 |
| SY 611 CL2 | 72.3 | 42.3 | 29.1 | 37.4 | 22.7 | 61.1 | 31.8 | 45.0 | 35.4 | 42.1 |
| Mean (n=20) | 77.4 | 45.5 | 37.1 | 41.6 | 25.5 | 62.5 | 34.2 | 45.2 | 38.2 | 45.5 |
| *P* value | <0.001 | ns | <0.001 | <0.001 | <0.05 | ns | <0.01 | <0.001 | ns | <0.001 |
| LSD (0.05) | 5.9 | - | 5.1 | 4.6 | 4.6 | - | 5.7 | 4.0 | - | 2.1 |

Table 2. Grain yield (bu/ac) comparisons between MT1939 and check varieties grown in 30 Advanced Yield Trial (AYT) **rain-fed and irrigated** location-years from 2020 to 2022. Twenty common varieties were grown in all three years and were incluced in the combined analysis. Underlined values indicate varieties were not significantly different from the highest yielding line. Table sorted based on combined means.

| Loc. | Bozeman (rain-fed) | Conrad | Fort Benton | Havre | Hingham/ Rudyard | Huntley/ Billings | Moccasin | Sidney (rain-fed) | Williston | Bozeman (irrigated) | Kalispell (high rainfall) | Sidney (irrigated) | Combined Loc/Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2020-2022 | 2021 | 2020-2022 | 2020-2022 | 2021-2022/ 2021 | 2020-2021/ 2022 | 2020-2022 | 2020-2022 | 2021-2022 | 2022 | 2021-2022 | 2020-2022 | n = 30 |
| **MT 1939** | **84.7** | **54.1** | **43.3** | **43.9** | **27.6** | **68.1** | **38.0** | **50.1** | **39.9** | **113.7** | **101.4** | **84.7** | **59.1** |
| MT 1809 | 86.1 | 42.8 | 41.2 | 47.9 | 29.8 | 66.0 | 37.2 | 50.2 | 41.5 | 112.3 | 90.3 | 87.3 | 58.5 |
| DAGMAR | 81.9 | 48.2 | 38.5 | 46.6 | 26.7 | 63.1 | 38.5 | 50.1 | 38.3 | 105.3 | 86.3 | 86.0 | 56.6 |
| NS PRESSER CLP | 79.9 | 50.2 | 39.2 | 41.1 | 29.8 | 66.7 | 37.2 | 51.2 | 41.3 | 105.1 | 89.2 | 82.3 | 56.5 |
| VIDA | 82.8 | 44.6 | 38.7 | 44.1 | 27.8 | 65.9 | 37.3 | 49.7 | 41.0 | 107.0 | 82.3 | 84.4 | 56.3 |
| MT SIDNEY | 77.0 | 46.5 | 34.9 | 40.9 | 26.9 | 65.0 | 34.9 | 46.8 | 39.2 | 102.4 | 97.7 | 82.6 | 55.0 |
| MS RANCHERO | 83.2 | 48.9 | 34.5 | 39.7 | 27.3 | 58.8 | 36.6 | 42.4 | 35.7 | 105.2 | 94.1 | 86.7 | 54.8 |
| WB 9719 | 80.8 | 45.1 | 39.8 | 40.6 | 27.2 | 62.3 | 29.4 | 45.9 | 37.1 | 113.2 | 84.8 | 86.5 | 54.6 |
| SY ROCKFORD | 83.7 | 46.9 | 30.8 | 40.9 | 20.8 | 61.8 | 35.3 | 45.4 | 40.5 | 110.7 | 93.0 | 84.0 | 54.4 |
| DUCLAIR | 76.1 | 38.7 | 41.8 | 41.7 | 22.8 | 65.2 | 34.0 | 39.2 | 35.4 | 114.2 | 92.5 | 80.0 | 53.7 |
| SY LONGMIRE | 71.2 | 43.6 | 39.2 | 41.5 | 22.7 | 63.2 | 28.9 | 42.2 | 41.1 | 109.8 | 89.3 | 87.0 | 53.4 |
| LANNING | 77.8 | 46.4 | 36.6 | 40.3 | 24.1 | 59.0 | 37.3 | 45.2 | 38.0 | 100.0 | 80.7 | 82.7 | 53.1 |
| WB 9879 CLP | 73.7 | 50.1 | 40.6 | 42.1 | 24.9 | 62.0 | 33.8 | 42.1 | 38.0 | 107.4 | 81.2 | 78.7 | 53.0 |
| CHOTEAU | 74.5 | 43.6 | 39.7 | 42.4 | 22.6 | 62.2 | 31.7 | 43.6 | 36.6 | 109.6 | 81.6 | 78.9 | 52.5 |
| REEDER | 73.4 | 47.7 | 35.4 | 40.6 | 25.5 | 59.0 | 33.6 | 47.1 | 37.8 | 96.5 | 80.8 | 82.8 | 52.4 |
| WB GUNNISON | 71.4 | 46.0 | 37.9 | 42.2 | 27.9 | 60.3 | 34.1 | 39.9 | 35.4 | 102.2 | 87.1 | 77.1 | 52.2 |
| SY 611 CL2 | 72.3 | 42.3 | 29.1 | 37.4 | 22.7 | 61.1 | 31.8 | 45.0 | 35.4 | 102.7 | 84.6 | 86.4 | 51.4 |
| SY INGMAR | 76.3 | 41.7 | 29.7 | 39.6 | 21.8 | 59.4 | 27.0 | 46.0 | 40.8 | 98.8 | 82.8 | 84.0 | 51.3 |
| CORBIN | 72.5 | 46.4 | 34.6 | 40.9 | 25.3 | 59.1 | 30.8 | 39.5 | 35.0 | 101.6 | 88.8 | 75.6 | 51.0 |
| MCNEAL | 67.8 | 35.6 | 37.4 | 38.4 | 24.8 | 60.7 | 35.8 | 41.7 | 37.2 | 93.3 | 78.5 | 76.7 | 50.4 |
| Mean (n=20) | 77.4 | 45.5 | 37.1 | 41.6 | 25.5 | 62.5 | 34.2 | 45.2 | 38.2 | 105.5 | 87.3 | 82.7 | 54.0 |
| *P* value | <0.001 | ns | <0.001 | <0.001 | <0.05 | ns | <0.01 | <0.001 | ns | <0.001 | ns | ns | <0.001 |
| LSD (0.05) | 5.9 | - | 5.1 | 4.6 | 4.6 | - | 5.7 | 4.0 | - | 5.4 | - | - | 2.2 |

Table 3. Grain protein content (%) comparisons between MT1939 and check varieties grown in 30 Advanced Yield Trial (AYT) **rain-fed and irrigated** location-years from 2020 to 2022. Twenty common varieties were grown in all three years and were included in the combined analysis. Underlined values indicate varieties were not significantly different from the highest grain protein content value. Table sorted based on combined means.

| Loc. | Bozeman (rain-fed) | Conrad | Fort Benton | Havre | Hingham/ Rudyard | Huntley/ Billings | Moccasin | Sidney (dry) | Williston | Bozeman (irrigated) | Sidney (irrigated) | Kalispell (high rainfall) | Combined Loc/Yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2020-2022 | 2021 | 2020-2022 | 2020-2022 | 2021-2022/ 2021 | 2020-2021/ 2022 | 2020-2022 | 2020-2022 | 2021-2022 | 2022 | 2020-2022 | 2021-2022 | n = 30 |
| SY INGMAR | 15.3 | 14.3 | 16.5 | 15.4 | 16.1 | 15.7 | 17.4 | 14.9 | 15.5 | 15.2 | 14.6 | 11.3 | 15.4 |
| LANNING | 15.5 | 13.0 | 16.1 | 15.4 | 16.2 | 15.8 | 15.8 | 15.2 | 15.8 | 15.6 | 15.3 | 11.2 | 15.3 |
| WB 9879 CLP | 15.2 | 13.2 | 16.0 | 15.6 | 15.9 | 15.2 | 16.5 | 15.2 | 16.1 | 14.7 | 14.5 | 10.6 | 15.2 |
| DAGMAR | 15.5 | 14.5 | 15.7 | 15.5 | 15.9 | 15.4 | 15.8 | 15.0 | 15.2 | 15.7 | 15.1 | 10.7 | 15.1 |
| SY 611 CL2 | 15.1 | 13.9 | 16.0 | 15.1 | 15.8 | 15.1 | 15.9 | 15.3 | 16.0 | 15.2 | 14.5 | 10.6 | 15.0 |
| MCNEAL | 15.3 | 13.1 | 15.3 | 15.0 | 15.9 | 15.3 | 15.5 | 15.3 | 15.7 | 16.2 | 15.0 | 10.9 | 15.0 |
| SY LONGMIRE | 14.7 | 13.5 | 16.0 | 15.3 | 16.1 | 15.2 | 17.0 | 14.9 | 15.4 | 14.4 | 14.3 | 10.6 | 15.0 |
| CHOTEAU | 14.7 | 13.4 | 16.1 | 15.3 | 15.7 | 15.1 | 16.3 | 14.8 | 16.7 | 14.5 | 14.7 | 10.3 | 15.0 |
| MT 1809 | 15.4 | 12.9 | 15.4 | 15.1 | 15.9 | 15.2 | 15.8 | 15.0 | 15.6 | 15.6 | 14.5 | 10.5 | 14.9 |
| REEDER | 15.3 | 12.9 | 15.5 | 15.0 | 15.3 | 15.0 | 15.8 | 14.9 | 15.8 | 15.5 | 14.7 | 11.1 | 14.9 |
| CORBIN | 14.5 | 13.7 | 15.3 | 15.6 | 15.6 | 14.8 | 16.3 | 14.8 | 16.3 | 14.9 | 14.8 | 10.1 | 14.9 |
| DUCLAIR | 14.4 | 13.9 | 15.0 | 15.5 | 15.8 | 14.8 | 15.7 | 14.7 | 16.5 | 14.1 | 14.4 | 10.6 | 14.8 |
| MT SIDNEY | 14.8 | 13.3 | 15.6 | 15.4 | 15.5 | 14.5 | 15.8 | 14.7 | 15.4 | 15.0 | 14.3 | 10.9 | 14.8 |
| SY ROCKFORD | 14.6 | 13.9 | 15.4 | 15.2 | 15.7 | 14.9 | 15.9 | 14.8 | 14.7 | 14.0 | 14.2 | 11.2 | 14.7 |
| WB 9719 | 14.5 | 12.5 | 15.2 | 14.8 | 14.9 | 14.7 | 16.3 | 14.6 | 15.3 | 14.0 | 14.1 | 10.5 | 14.5 |
| NS PRESSER CLP | 15.1 | 12.9 | 15.6 | 14.8 | 14.8 | 15.0 | 15.6 | 14.2 | 14.9 | 15.0 | 13.9 | 10.6 | 14.5 |
| **MT 1939** | **14.6** | **13.3** | **15.3** | **14.9** | **14.6** | **14.5** | **15.4** | **14.0** | **15.5** | **14.8** | **14.2** | **11.0** | **14.5** |
| VIDA | 14.4 | 12.9 | 14.9 | 14.7 | 14.8 | 14.6 | 15.5 | 14.0 | 15.4 | 14.5 | 14.1 | 10.4 | 14.3 |
| WB GUNNISON | 14.1 | 12.5 | 14.7 | 14.5 | 14.8 | 14.4 | 15.6 | 14.3 | 15.3 | 13.8 | 13.9 | 10.6 | 14.2 |
| MS RANCHERO | 14.3 | 13.3 | 15.1 | 14.7 | 14.2 | 14.6 | 15.2 | 13.9 | 15.4 | 14.1 | 13.8 | 10.3 | 14.2 |
| Mean (n=20) | 14.9 | 13.4 | 15.5 | 15.1 | 15.5 | 15.0 | 15.9 | 14.7 | 15.6 | 14.8 | 14.4 | 10.7 | 14.8 |
| *P* value | <0.001 | ns | <0.001 | <0.001 | <0.01 | <0.01 | <0.001 | <0.001 | ns | ns | <0.001 | ns | <0.001 |
| LSD (0.05) | 0.6 | - | 0.9 | 0.3 | 1.0 | 0.7 | 1.0 | 0.6 | - | - | 0.7 | - | 0.2 |

Table 4. Agronomic trait comparisons between MT1939 and check varieties grown in 30 Advanced Yield Trial (AYT) rain-fed and irrigated location-years from 2020 to 2022. Twenty common varieties were grown in all three years and were included in the combined analysis. Underlined values indicate varieties were not significantly different from the optimum value. After MT1939, the table was sorted alphabetically based on variety name.

| | Test weight (lb/bu) | Heading date (julian) | Plant height (inch) | Stem solidness[a] (5-25) | Sawfly cutting (%) (Fort Benton, 21-22) | Sawfly cutting (%) (Havre, 21-22) | Aluminum Tolerance[b] (Rockford, WA 20,22) |
|---|---|---|---|---|---|---|---|
| Environments | 29 | 20 | 29 | 3 | 2 | 2 | 2 |
| **MT 1939** | **60.3** | **176.7** | **27.5** | **20.4** | **26.4** | **27.0** | **T** |
| CHOTEAU | 59.9 | 177.8 | 27.7 | 21.7 | 20.0 | 7.0 | T |
| CORBIN | 60.7 | 175.9 | 27.8 | 13.3 | 24.7 | 6.5 | S |
| DAGMAR | 60.8 | 175.5 | 28.7 | 19.4 | 23.9 | 2.7 | S |
| DUCLAIR | 59.3 | 175.8 | 27.9 | 20.0 | 19.8 | 3.9 | MT |
| LANNING | 59.7 | 175.9 | 26.8 | 7.9 | 74.3 | 51.0 | T |
| MCNEAL | 59.3 | 179.3 | 29.1 | 7.7 | 76.4 | 40.4 | T |
| MS RANCHERO | 59.9 | 176.4 | 28.5 | 8.3 | 67.9 | 35.4 | S |
| MT 1809 | 59.5 | 177.7 | 28.0 | 12.5 | 36.9 | 23.2 | MT |
| MT SIDNEY | 60.7 | 176.7 | 28.1 | 9.7 | 68.6 | 18.1 | S |
| NS PRESSER CLP | 58.9 | 180.5 | 29.7 | 7.7 | 69.8 | 22.6 | S |
| REEDER | 60.3 | 178.1 | 28.7 | 7.3 | 56.6 | 42.9 | T |
| SY 611 CL2 | 60.8 | 177.0 | 25.6 | 9.3 | 70.1 | 48.4 | S |
| SY INGMAR | 60.7 | 177.9 | 26.8 | 8.6 | 61.1 | 36.9 | S |
| SY LONGMIRE | 60.9 | 177.5 | 27.2 | 20.3 | 27.2 | 14.0 | T |
| SY ROCKFORD | 59.2 | 179.6 | 27.7 | 8.2 | 74.4 | 48.0 | T |
| VIDA | 59.9 | 178.6 | 28.4 | 13.3 | 26.7 | 14.6 | S |
| WB 9719 | 62.3 | 179.3 | 26.7 | 6.6 | 61.4 | 50.7 | - |
| WB 9879 CLP | 60.1 | 178.3 | 27.6 | 23.0 | 11.3 | 2.1 | T |
| WB GUNNISON | 60.7 | 177.7 | 26.8 | 12.7 | 22.1 | 3.4 | S |
| Mean (n=20) | 60.2 | 177.6 | 27.8 | 12.9 | 46.0 | 24.9 | |
| *P* value | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | |
| LSD (0.05) | 0.4 | 0.6 | 0.6 | 1.7 | 27.8 | 18.9 | |

[a]5 = hollow stem, 25 = solid stem

[b]T = Tolerant, MT = Mostly Tolerant, S = Susceptible (Dr. Mike Pumphery, WSU, Pullman, WA)

Table 5. Yield and agronomic comparisons of MT 1939 with elite varieties grown in 29 Spring Wheat **Off-Station Yield Trial** location-years from 2021 to 2022. Varieties were grown in 22 rainfed and 7 irrigated environments. Twelve common varities 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.

| | YIELD (bu/ac) | | | TEST WEIGHT (lb/bu) | | | GRAIN PROTEIN (%) | | | HEADING DATE (Julian) | | | HEIGHT (Inches) | | | SAWFLY CUT (%) | FALLING NUMBER | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Environments | 22 | 7 | 29 | 22 | 7 | 29 | 22 | 7 | 29 | 4 | 1 | 5 | 22 | 7 | 29 | 9 | 4 | 1 | 5 |
| Line/Variety | RAINFED | IRRI | TOTAL | RAINFED | IRRI | TOTAL | RAINFED | IRRI | TOTAL | RAINFED | IRRI | TOTAL | RAINFED | IRRI | TOTAL | TOTAL | RAINFED | IRRI | TOTAL |
| **MT 1939** | **35.1** | **89.0** | **48.1** | **57.6** | **60.4** | **58.3** | **15.7** | **13.9** | **15.3** | **177.7** | **164.6** | **175.1** | **23.5** | **32.7** | **25.7** | **14.2** | **367** | **375** | **369** |
| DAGMAR | 34.4 | 87.0 | 47.1 | 58.6 | 61.0 | 59.1 | 16.2 | 14.5 | 15.8 | 177.5 | 163.0 | 174.6 | 24.2 | 33.8 | 26.5 | 9.8 | 401 | 363 | 391 |
| MT 1809 | 32.6 | 89.1 | 46.2 | 56.8 | 60.0 | 57.6 | 16.5 | 14.4 | 16.0 | 178.6 | 164.8 | 175.8 | 23.4 | 33.0 | 25.7 | 22.7 | 407 | 348 | 393 |
| VIDA | 32.3 | 86.1 | 45.3 | 57.6 | 60.0 | 58.2 | 15.6 | 14.2 | 15.3 | 179.2 | 165.9 | 176.5 | 23.9 | 33.6 | 26.2 | 18.2 | 372 | 348 | 366 |
| MT SIDNEY | 31.4 | 86.1 | 44.6 | 58.0 | 60.7 | 58.7 | 16.0 | 14.0 | 15.5 | 178.1 | 164.3 | 175.4 | 24.4 | 33.2 | 26.5 | 24.0 | 414 | 357 | 400 |
| LANNING | 31.6 | 84.4 | 44.4 | 57.0 | 60.5 | 57.8 | 16.4 | 14.8 | 16.0 | 176.5 | 162.4 | 173.7 | 22.9 | 32.0 | 25.1 | 32.8 | 383 | 357 | 376 |
| DUCLAIR | 31.5 | 82.9 | 43.9 | 56.7 | 59.7 | 57.4 | 16.2 | 14.3 | 15.8 | 177.5 | 163.5 | 174.7 | 23.8 | 33.0 | 26.0 | 10.0 | 357 | 357 | 357 |
| REEDER | 29.1 | 87.3 | 43.1 | 57.9 | 61.3 | 58.7 | 16.2 | 14.7 | 15.8 | 179.0 | 165.6 | 176.3 | 24.1 | 34.9 | 26.7 | 30.3 | 375 | 358 | 371 |
| SY SOREN | 29.8 | 85.1 | 43.1 | 57.7 | 61.3 | 58.6 | 16.7 | 14.5 | 16.2 | 178.4 | 165.4 | 175.8 | 22.6 | 31.0 | 24.6 | 25.1 | 443 | 359 | 422 |
| NS PRESSER CLP | 30.9 | 81.5 | 43.1 | 56.7 | 59.3 | 57.3 | 15.8 | 14.2 | 15.4 | 180.8 | 167.1 | 178.0 | 24.4 | 34.1 | 26.8 | 24.8 | 397 | 335 | 381 |
| BRENNAN | 29.6 | 82.0 | 42.2 | 58.7 | 61.9 | 59.4 | 16.3 | 14.5 | 15.9 | 177.4 | 164.6 | 174.8 | 22.4 | 30.7 | 24.4 | 26.8 | 418 | 376 | 408 |
| SY INGMAR | 29.3 | 82.5 | 42.1 | 57.9 | 60.9 | 58.6 | 16.6 | 14.5 | 16.1 | 179.3 | 166.8 | 176.8 | 22.8 | 32.0 | 25.0 | 27.5 | 412 | 354 | 397 |
| Mean(n=12) | 31.5 | 85.2 | 44.4 | 57.6 | 60.6 | 58.3 | 16.2 | 14.4 | 15.7 | 178.3 | 164.8 | 175.6 | 23.5 | 32.8 | 25.8 | 22.2 | 395 | 357 | 386 |
| *P* value | <0.001 | ns | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.01 | <0.001 | <0.001 | - | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | - | <0.001 |
| LSD (0.05) | 2.2 | - | 2.2 | 0.7 | 1.1 | 0.6 | 0.2 | 0.5 | 0.2 | 1.3 | - | 1.1 | 0.7 | 1.6 | 0.6 | 10.1 | 28 | - | 27 |

Table 6. 2021 Fungal leaf spot evaluation of MT1939 compared to other regionally adapted varieties (Dr. Zhaohui Liu, NDSU, Fargo, ND).

| Line | Ptr ToxA[1] | Ptr Race 1[2] | Ptr Race 5[2] | Sn4[3] |
|---|---|---|---|---|
| **MT 1939** | **0** | **3.5** | **3.5** | **0.5** |
| BRENNAN | 0 | 2.5 | 2 | 2.5 |
| SY SOREN | 0 | 2 | 1 | 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 |
| MS RANCHERO | 0 | 1.5 | 2 | 4 |
| NS PRESSER CLP | 1 | 2.5 | 1.5 | 3.5 |
| REEDER | 1 | 2 | 4.5 | 3.5 |
| SY INGMAR | 1 | 3.5 | 3.5 | 3 |
| SY ROCKFORD | 0 | 1.5 | 1 | 3.5 |
| VIDA | 0 | 2 | 1 | 2 |
| WB 9879 CLP | 0 | 4 | 2 | 1 |
| WB GUNNISON | 1 | 3.5 | 2.5 | 3.5 |
| MT SIDNEY | 0 | 2 | 4 | 0.5 |
| MT 1809 | 0 | 2 | 2 | 2.5 |
| Salamouni (check) | 0 | 1.5 | 1 | 1 |
| Glenelea (check) | 1 | 4 | 2.5 | 4 |

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

[2]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.

[3]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 MT1939 compared to other regionally adapted control varieties evaluated in Sidney, MT from 2019 to 2022. Table sorted based on DON values. (Dr. Frankie Crutcher, MSU-EARC, Sidney, MT)

| Variety | % Severity[a] | % Incidence[b] | Disease Index[c] | % FDK[d] | DON (ppm) |
|---|---|---|---|---|---|
| **2020** | | | | | |
| SY Ingmar | 1.1 C | 6.7 D | 0.1 B | 4.0 C | 0.7 B |
| MT 1809 | 1.7 C | 18.9 CD | 0.4 B | 3.3 C | 0.8 B |
| MT Sidney | 1.2 C | 15.6 CD | 0.2 B | 3.3 C | 0.8 B |
| Reeder | 3.2 BC | 25.6 B-D | 0.8 B | 4.7 C | 1.6 B |
| Dagmar | 7.9 BC | 50.0 AB | 4.0 B | 5.3 C | 2.0 B |
| Vida | 5.2 BC | 34.4 B-D | 2.0 B | 6.0 C | 2.7 AB |
| Lanning | 7.4 BC | 51.1 AB | 4.1 B | 7.3 BC | 3.9 AB |
| McNeal | 33.9 A | 78.9 A | 26.9 A | 18.3 A | 4.1 AB |
| **MT 1939** | **10.2 B** | **38.9 BC** | **4.1 B** | **14.3 AB** | **6.7 A** |
| **Mean** | 8 | 35.6 | 4.7 | 7.4 | 2.6 |
| ***P* value** | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.002 |
| **HSD (0.05)** | 8 | 30.9 | 7.3 | 7.6 | 4.4 |
| **2021** | | | | | |
| Vida | 12.9 B-D | 46.7 AB | 6.1 B | 0.3 B | 0.2 B |
| MT 1809 | 4.8 CD | 26.7 B | 2.2 B | 0.5 B | 0.3 AB |
| Lanning | 8.3 B-D | 46.7 AB | 4.0 B | 1.3 B | 0.3 AB |
| MT Sidney | 11.8 B-D | 45.6 B | 5.5 B | 3.3 B | 0.4 AB |
| SY Ingmar | 2.9 D | 31.7 B | 0.9 B | 0.5 B | 0.5 AB |
| Dagmar | 13.7 B-D | 55.6 AB | 7.6 B | 1.7 B | 0.7 AB |
| Reeder | 15.5 BC | 53.3 AB | 8.2 B | 1.7 B | 1.1 AB |
| **MT 1939** | **18.6 B** | **56.7 AB** | **10.9 B** | **1.0 B** | **1.6 AB** |
| McNeal | 30.0 A | 75.6 A | 22.9 A | 11.7 A | 2.5 A |
| **Mean** | 13.7 | 50 | 8 | 2.7 | 0.8 |
| ***P* value** | <0.0001 | 0.0036 | <0.0001 | <0.0001 | 0.0495 |
| **HSD (0.05)** | 9.8 | 29.5 | 9.2 | 5.7 | 2.3 |
| **2022** | | | | | |
| MT Sidney | 28.1 C | 90 | 25.2 C | 48.3 | 7.3 B |
| MT 1809 | 33.0 BC | 94.4 | 31.3 BC | 33.3 | 10.6 B |
| SY 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 |
| McNeal | 68.1 A | 97.8 | 66.6 A | 60 | 28.8 AB |
| **MT 1939** | **58.2 AB** | **100** | **58.2 AB** | **60** | **36.3 A** |
| Lanning | 44.7 A-C | 100 | 44.7 A-C | 45 | 38.8 A |
| **Mean** | 43 | 96.1 | 41.6 | 42.9 | 19.5 |
| ***P* value** | 0.0019 | 0.05 | 0.0017 | 0.3736 | 0.003 |
| **HSD (0.05)** | 27 | 14.1 | 28.3 | 42.5 | 28.4 |

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

[a]Severity: Average percent area of head covered by disease. Thirty heads were evaluated for each plot.

[d]Fusarium damaged kernels

Table 8. 2022 spring wheat stripe rust (*Puccinia striiformis*) evaluation under natural infection, 2022 (Dr. Xianming Chen, USDA-ARS, Pullman, WA).

| Location | Pullman, WA | | Mt. Vernon, WA[b] | | | | Central Ferry, WA | |
|---|---|---|---|---|---|---|---|---|
| Observation Date | 7/5 | | 5/19 | | 6/27 | | 6/23 | |
| Growth Stage | Fks 10.54 | | Fks 2 | | Fks 10.54 | | Fks 10.5 | |
| InfectionType (IT)[a]/Severity(%) | IT | % | IT | % | IT | % | IT | % |
| **MT 1939** | **7** | **70** | **8** | **20** | **8** | **80** | **8** | **80** |
| CHOTEAU | 8 | 70 | 8 | 20 | 3,8 | 50,80 | 8 | 40 |
| CORBIN | 5 | 60 | 8 | 10 | 8 | 90 | 8 | 30 |
| DAGMAR | 3 | 30 | 8 | 30 | 8 | 80 | 5 | 40 |
| DUCLAIR | 7 | 70 | 8 | 30 | 7 | 80 | 8 | 80 |
| LANNING | 7 | 70 | 8 | 20 | 7 | 80 | 8 | 40 |
| MCNEAL | 8 | 60 | 8 | 20 | 9 | 100 | 9 | 90 |
| MS Ranchero | 3 | 30 | 8 | 20 | 2 | 10 | 2 | 10 |
| MT 1809 | 8 | 70 | 8 | 30 | 8 | 70 | 8 | 40 |
| MT SIDNEY | 8 | 50 | 8 | 20 | 8 | 80 | 8 | 50 |
| NS PRESSER CLP | 8 | 80 | 8 | 30 | 6 | 70 | 8 | 40 |
| REEDER | 8 | 80 | 8 | 20 | 8 | 90 | 2 | 15 |
| SY 611 CL2 | 3 | 30 | 8 | 30 | 9 | 90 | 8 | 30 |
| SY INGMAR | 8 | 80 | 8 | 30 | 8 | 90 | 2 | 10 |
| SY Longmire | 8 | 80 | 7 | 30 | 9 | 90 | 5 | 40 |
| SY ROCKFORD | 8 | 80 | 8 | 10 | 8 | 90 | 8 | 80 |
| VIDA | 8 | 60 | 3 | 20 | 5 | 60 | 2 | 10 |
| WB 9879 CLP | 3 | 30 | 8 | 20 | 3 | 20 | 8 | 60 |
| WB GUNNISON | 8 | 80 | 8 | 20 | 8 | 90 | 2 | 15 |

[a] 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.

[b] 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-plan (HTAP) resistance.

Table 9. 2021 hard red spring wheat uniform regional nursery seedling and field stem rust (*Puccinia graminis* ) scores. (Matthew Rouse, USDA-ARS, St. Paul, MN).

| | Race (Seedling Scores)[a] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Line | QFCSC 06ND76C | QTHJC 75ND717C | MCCFC 59KS19 | RCRSC 77ND82A | RKRQC 99KS76A-1 | TPMKC 74MN1409 | TTTTF 01MN84A-1-2 | GFMNC 12WA147-2 | QCCSM 75WA165-2A | Adult plant stem rust[b] |
| **MT1939** | **;** | **2-** | **;2-** | **2-** | **2** | **2-** | **1;** | **;2-** | **;1-** | **5R-MR** |
| Marquis | 2- | 22+ | 4 | 3+ | - | 3+ | 23 | 2+ | 2 | 60MS-S |
| Chris | 0 | 1+ | 0; | ; | - | 3- | ; | 0 | 0 | 30MS |
| Prosper | 0; | 2- | ;1- | ;2- | 2- | 2- | ;1 | ; | ;2- | 30R-MR |
| Linkert | ; | ;2- | ;2- | ; | 2- | 2- | ;;;1? | ;2- | 2- | 5R-MR |
| Boost | ; | 2- | ; | 2- | 2 | 2- | ;1/2 | 0; | ;2- | 60MR-MS |
| MTSidney | ; | 2 | 2-; | 2-; | 2 | 2- | ;1 | ; | 2-; | 10R-MR |
| MT1809 | 0; | 2- | 2-; | ;2- | 2 | 2- | ;1 | ;2- | ;2- | 5R-MR |
| MT1855 | 1; | 2- | 2- | 2- | 2-2 | 2 | 2 | 2-; | 12- | 30MS-S |
| MT1927 | ;2- | 2- | 2-; | 2- | 2 | 2- | 2 | 2-; | 2-; | 5MR |
| Line E (check) | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 100S |
| LMPG-6 (check) | 3 | 3- | 3+ | 3 | 4 | 3 | 3 | 3 | 3+ | 90S |
| NA101/MqSr7a (check) | 13c | 3+ | 3+ | 13 | 1+3- | 4 | ;1 | 23c | 1+3- | 60MS-S |

[a]Seedling rating scale: 0 to 4 infection type scale where 3 - 4 considered susceptible; "/" denotes hetergeneous, the predominant type given first; "LIF" denotes low infection frequency, or fewer number of pustules; "C" stands for excessive chlorosis; "N" stands for excessive necrosis; "Sr2M" referred to seedling chlorosis, similar to Sr2 expression in seedling under certain environments.

[b]Field stem rust nusery was inoculated with a bulk of 5 races: QFCSC (95MN1080), QTHJC (69MN399), RCRSC (00MN99C), RTQQC (04MN74-1), and TMPKC (74MN1409). Stem rust disease severity (estimated % of stem tissue covered by rust pustules) and infection responses (R, MR, MS, and S) were noted at growth stages between milk and soft dough.

Table 10. Combined analysis of end-use quality between MT1939 and check varieties grown in six Advanced Yield Trial (AYT) location-years from 2020 to 2021. End-Use quality samples were from Bozeman, MT (2020-2021), Havre, MT (2020), Moccasin (2020) and Sidney, MT (2020-2021). Thirty-one entries were common in all locations and used in the combined analysis. Underlined values indicate values that were not significantly different from the optimum value. After MT1939, the table was sorted alphabetically based on variety name.

| Variety/Line | Flour yield (%) | Flour protein (%, 14% m.b.) | Mixing tolerance | Mixo mixing time (min.) | Mixo water absorption (%) | Bake mix time (min.) | Bake water absorption (%) | Loaf volume (cc) |
|---|---|---|---|---|---|---|---|---|
| **MT 1939** | **69.5** | **12.8** | **2.8** | **3.6** | **67.5** | **8.4** | **78.0** | **1059** |
| CHOTEAU | 71.0 | 13.1 | 1.5 | 3.2 | 67.5 | 6.1 | 76.9 | 1120 |
| CORBIN | 71.3 | 12.6 | 2.2 | 5.1 | 66.0 | 11.4 | 75.8 | 996 |
| DAGMAR | 70.1 | 13.2 | 2.8 | 3.7 | 67.9 | 7.3 | 78.0 | 1098 |
| DUCLAIR | 70.3 | 12.8 | 3.2 | 3.9 | 67.0 | 8.6 | 77.1 | 1117 |
| LANNING | 70.3 | 13.6 | 2.8 | 4.1 | 68.8 | 9.1 | 79.8 | 1162 |
| MCNEAL | 69.1 | 12.8 | 3.8 | 6.4 | 69.5 | **14.6** | 80.4 | 1140 |
| MT 1809 | 71.2 | 12.9 | 2.3 | 2.8 | 67.3 | 5.1 | 77.0 | 1110 |
| MT SIDNEY | 70.8 | 13.0 | 1.8 | 4.4 | 66.6 | 10.1 | 77.0 | 1086 |
| REEDER | 69.4 | 13.1 | 1.8 | 3.0 | 65.1 | 5.6 | 75.2 | 1101 |
| SY INGMAR | 70.9 | 13.7 | 3.5 | 5.1 | 67.5 | 12.5 | 78.9 | 1148 |
| VIDA | 72.1 | 12.3 | 1.7 | 3.2 | 66.8 | 6.8 | 76.0 | 1097 |
| WB 9879 CLP | 69.1 | 13.5 | 2.0 | 2.5 | 66.7 | 3.8 | 75.8 | 1036 |
| MEAN (n=31) | 70.2 | 13.0 | 2.8 | 4.3 | 67.3 | 9.4 | 77.7 | 1091 |
| *P* value | <0.001 | <0.001 | <0.001 | <0.001 | <0.01 | <0.001 | <0.001 | <0.001 |
| LSD (0.05) | 1.3 | 0.7 | 1.0 | 1.4 | 2.6 | 4.0 | 2.9 | 85 |