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MEMORANDUM

TO: Wheat Variety Release Committee

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

DATE: January 24th, 2024

RE: Proposal for MAES release of MT2049 for licensing.

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

Motion: Release MT2049 hard red spring wheat for licensing.

Pedigree: Lanning/MT 1415

Breeder Seed Available: 15 Bushels

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: MT2049 is a high tillering, early maturing, short stature line with good yield potential in Montana rainfed growing environments, including being the top yielding line at the Central Agricultural Research Center (CARC). MT 2049 has good grain protein content, good test weight and moderate tolerance to plant available Al. This line is susceptible to wheat stem sawfly and is prone to lodging in high production environments.

Breeding History and Agronomic Performance:

MT2049 was derived from the cross 'Lanning' (Heo et al., 2016) /MT 1415. 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. MT 1415 was an MAES experimental line that was not released and was derived from the cross 'Vida' (Lanning et al., 2006)/MT0909. Vida was released by the Montana Agriculture Experiment Station (MAES) in 2006 for having high yield in rainfed environments and is currently the most widely grown spring wheat variety in Montana.

Yield and other agronomic measurements were collected from the Advanced Yield Trial (AYT) during the 2021 – 2023 growing seasons totaling 34 location-years including 26 rainfed and 8 irrigated growing environments. In rainfed environments, MT2049 was in the top yielding statistical group in 7 out of 9 locations and was the top yielding line at CARC (Moccasin, MT) (Table 1). Across all environments, combined mean analysis placed MT2049 in the top yielding statistical group at 64.3 bu/ac and had similar yield to Vida (Table 2). Analyzing grain protein content across all environments, MT2049 exhibited a 0.4% increase compared to Vida but was 0.3% lower than 'Dagmar' (Heo et al., 2020) (Table 3). Test weight was 59.6 lbs/bu across all environments (Table 4). MT2049's heading date and maturity were 3.3 days earlier than Vida. Solid-stem scores for MT2049, Reeder, and Dagmar were 11.0, 7.2, and 17.4, respectively. Sawfly cutting data collected at Fort Benton, for MT 2049, Reeder and Dagmar was 65.9%, 56.6% and 23.9% respectively (Table 4). In Havre, MT, sawfly cutting percentages for MT2049, Reeder, and Dagmar were 43.0%, 42.9%, and 2.7%, respectively. MT 2049 is not resistant to sawfly. Lastly, MT2049 is moderately tolerant to plant available aluminum (Table 4).

Data from 28 Off-Station Yield Trials, encompassing 21 rainfed and 7 irrigated environments during the 2022-2023 growing seasons, facilitated additional comparisons between MT 2049 and commonly grown varieties in Montana (Table 5). In rainfed conditions and across all environments, MT2049 ranked in the top yielding statistical group. However, yield in irrigated environments were lower compared to other varieties, potentially attributed to a high incidence of lodging. Sawfly cutting was recorded in seven locations where MT2049 was cut 34.1% verses Reeder and Dagmar that were cut 31.8% and 12.6%, respectively. Falling numbers were obtained

from nine off-station environments where MT 2049 had an overall falling number of 416, which was close to average (417) among the other tested varieties.

MT2049 was evaluated in several disease screening nurseries. MT2049 is susceptible to prevalent races of *P. tritici-repentis* and is resistant to the predominant North Dakota *Septoria nodorum* isolate (Table 6). MT2049 has a similar level of fusarium head blight susceptibility as Vida over three years of testing at the Eastern Ag Research Center (Table 7). This line is also susceptible to stripe rust (Table 8).

End-use quality was tested at eight AYT locations grown in 2021 - 2023. Among the 32 lines compared, MT2049 had higher mixing tolerance and bake water absorption than Vida (Table 9). Mixing tolerance and water absorption was lower than Dagmar. Overall, MT2049 end-use quality is average.

References:

Heo, H.-Y., Lanning, S. P., Lamb, P. F., Nash, D., Wichman, D. M., Eberly, J., . . . Talbert, L. E. (2020). Registration of 'Dagmar' hard red spring wheat. *Journal of Plant Registrations*, 14(1), 43-48. doi:https://doi.org/10.1002/plr2.20023

Heo, H.-Y., Lanning, S. P., Lamb, P. F., Nash, D., Wichman, D. M., Kephart, K. D., . . . Talbert, L. E. (2016). Registration of 'Lanning' Hard Red Spring Wheat. *Journal of Plant Registrations*, 10(3), 287-290. doi:10.3198/jpr2016.03.0016crc

Lanning, S. P., Carlson, G. R., Nash, D., Wichman, D. M., Kephart, K. D., Stougaard, R. N., . . . Talbert, L. E. (2006). Registration of 'Vida' wheat. *Crop Science*, 46(5), 2315-2316. doi:10.2135/cropsci2006.03.0167

Table 1. Grain yield (bu/ac) comparisons between MT2049 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 incluced 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	**95.5**	**38.3**	**68.0**	**35.3**	**58.6**	**64.0**	**48.8**	**37.7**	**42.5**	**54.3**
MT DUTTON	**95.4**	**40.0**	**67.6**	**33.1**	**51.3**	**65.0**	**47.3**	**39.5**	**45.0**	**53.8**
DAGMAR	**91.2**	**41.6**	**67.5**	**36.4**	**54.6**	**65.7**	**45.3**	**34.6**	**41.4**	**53.1**
MT 2030	**96.1**	36.0	**64.4**	**35.6**	**52.8**	**66.7**	**48.8**	**37.4**	36.1	**52.7**
VIDA	**89.8**	**38.4**	**67.0**	**33.2**	47.7	**63.2**	**49.6**	**38.9**	**42.4**	**52.2**
ROCKER	**92.1**	**39.2**	**66.9**	**32.8**	**50.8**	60.3	**49.0**	34.0	**40.3**	**51.7**
LCS ASCENT	**95.2**	**37.0**	**62.2**	**33.5**	**53.6**	**64.4**	41.1	34.2	**43.3**	**51.6**
MT 2049	**91.2**	**38.4**	**63.5**	**36.7**	49.5	**62.6**	43.9	**35.6**	**41.6**	51.4
WB 9516	**92.8**	**37.5**	**65.7**	26.2	**55.4**	59.9	**46.6**	**34.4**	37.2	50.6
MT 2050	87.6	**39.8**	**63.3**	**32.9**	**52.6**	60.1	**47.1**	34.1	36.9	50.5
LANNING	88.3	35.6	**62.8**	**33.0**	**50.7**	**62.7**	**45.8**	32.2	**40.1**	50.1
MT SIDNEY	**90.2**	33.5	**65.3**	**32.4**	50.3	61.9	43.4	33.6	**39.7**	50.0
SY ROCKFORD	**91.9**	**38.6**	**64.2**	**32.4**	**52.2**	60.4	37.1	29.4	**40.5**	49.6
WB 9719	**91.7**	35.1	**58.8**	26.6	50.4	59.9	**44.8**	**35.2**	**38.5**	49.0
REEDER	86.5	35.5	**61.6**	29.6	48.9	59.1	41.9	**35.5**	36.6	48.4
WB GUNNISON	80.2	**40.2**	58.1	27.4	**51.9**	54.1	**44.7**	**39.6**	**38.7**	48.3
DUCLAIR	**90.2**	34.3	**64.5**	**30.6**	45.2	52.6	44.2	**34.4**	37.5	48.2
SY LONGMIRE	85.3	33.1	**66.2**	24.9	49.1	55.9	**44.9**	33.9	**39.8**	48.1
CORBIN	78.3	35.7	57.0	27.6	**52.3**	52.9	42.1	**36.6**	36.6	46.6
AP SMITH	83.5	32.8	**61.3**	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	**40.1**	45.7
Mean (n=32)	**87.0**	**36.0**	**62.4**	**30.9**	**49.3**	**59.2**	**43.7**	**34.7**	**38.5**	**49.1**
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
LSD (0.05)	**7.7**	**5.5**	**9.6**	**7.1**	**8.2**	**4.2**	**5.2**	**5.3**	**6.8**	**2.8**

Table 2. Grain yield (bu/ac) comparisons between MT2049 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 incluced 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	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	**95.5**	**38.3**	**68.0**	**35.3**	**58.6**	**64.0**	**48.8**	**37.7**	**42.5**	**122.3**	**91.2**	**108.6**	**67.6**
MT DUTTON	**95.4**	**40.0**	**67.6**	**33.1**	**51.3**	**65.0**	**47.3**	**39.5**	**45.0**	**124.0**	**93.9**	**101.1**	**66.9**
DAGMAR	**91.2**	**41.6**	**67.5**	**36.4**	**54.6**	**65.7**	**45.3**	**34.6**	**41.4**	**119.4**	**95.6**	**98.9**	**66.0**
LCS ASCENT	**95.2**	**37.0**	**62.2**	**33.5**	**53.6**	**64.4**	41.1	34.2	**43.3**	**128.5**	**94.9**	**99.8**	**65.6**
WB 9516	**92.8**	**37.5**	**65.7**	26.2	**55.4**	59.9	**46.6**	**34.4**	37.2	**129.3**	**97.5**	**105.0**	**65.6**
MT 2030	**96.1**	36.0	**64.4**	**35.6**	**52.8**	**66.7**	**48.8**	**37.4**	36.1	**119.5**	**96.3**	94.1	**65.3**
MT 2049	**91.2**	**38.4**	**63.5**	**36.7**	49.5	**62.6**	43.9	**35.6**	**41.6**	**117.3**	**91.5**	**99.9**	**64.3**
MT SIDNEY	**90.2**	33.5	**65.3**	**32.4**	50.3	61.9	43.4	33.6	**39.7**	**119.5**	**93.2**	**106.4**	64.1
VIDA	**89.8**	**38.4**	**67.0**	**33.2**	47.7	**63.2**	**49.6**	**38.9**	**42.4**	114.2	**93.0**	91.1	64.0
ROCKER	**92.1**	**39.2**	**66.9**	**32.8**	**50.8**	60.3	**49.0**	34.0	**40.3**	114.2	**96.8**	91.2	64.0
MT 2050	87.6	**39.8**	**63.3**	**32.9**	**52.6**	60.1	**47.1**	34.1	36.9	**121.5**	**92.1**	**96.0**	63.7
SY ROCKFORD	**91.9**	**38.6**	**64.2**	**32.4**	**52.2**	60.4	37.1	29.4	**40.5**	**118.8**	**92.3**	92.7	62.5
WB 9719	**91.7**	35.1	**58.8**	26.6	50.4	59.9	**44.8**	**35.2**	**38.5**	111.1	**95.8**	**96.7**	62.1
LANNING	88.3	35.6	**62.8**	**33.0**	**50.7**	**62.7**	**45.8**	32.2	**40.1**	111.8	89.2	90.2	61.9
SY LONGMIRE	85.3	33.1	**66.2**	24.9	49.1	55.9	**44.9**	33.9	**39.8**	**114.5**	**93.8**	**96.4**	61.5
DUCLAIR	**90.2**	34.3	**64.5**	**30.6**	45.2	52.6	44.2	**34.4**	37.5	**117.9**	89.7	**96.2**	61.4
REEDER	86.5	35.5	**61.6**	29.6	48.9	59.1	41.9	**35.5**	36.6	104.4	**92.0**	91.0	60.2
WB GUNNISON	80.2	**40.2**	58.1	27.4	**51.9**	54.1	**44.7**	**39.6**	**38.7**	109.4	80.5	**96.9**	60.1
AP SMITH	83.5	32.8	**61.3**	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	**40.1**	107.4	86.2	87.8	57.7
CORBIN	78.3	35.7	57.0	27.6	**52.3**	52.9	42.1	**36.6**	36.6	99.8	79.0	94.5	57.7
Mean (n=32)	**87.0**	**36.0**	**62.4**	**30.9**	**49.3**	**59.2**	**43.7**	**34.7**	**38.5**	**113.8**	**90.4**	**95.3**	**61.7**
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
LSD (0.05)	**7.7**	**5.5**	**9.6**	**7.1**	**8.2**	**4.2**	**5.2**	**5.3**	**6.8**	**15.1**	**7.8**	**13.0**	**3.1**

Table 3. Grain protein content (%) comparisons between MT2049 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.	Bozeman (rainfed)	Havre	Huntley/ Billings	Moccasin	Conrad	Sidney (rainfed)	Fort Benton	Hingham	Williston	Bozeman (irrigated)	Sidney (irrigated)	Kalispell (high rainfall)	
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	Overall Mean
SY INGMAR	**15.4**	**16.3**	**15.4**	**17.6**	14.5	**14.2**	15.7	14.2	15.3	14.9	14.4	12.1	**15.0**
AP SMITH	**15.3**	**16.4**	**15.2**	**17.1**	14.6	**14.3**	15.6	**14.3**	**15.7**	14.9	14.2	**12.3**	**15.0**
LANNING	**15.5**	**16.2**	**15.4**	15.9	13.6	**14.1**	16.0	**14.3**	15.4	15.1	**14.8**	11.7	**14.8**
DAGMAR	**15.4**	**16.0**	**15.1**	15.7	14.4	**14.1**	15.4	14.2	15.1	15.3	**15.0**	11.5	**14.8**
SY LONGMIRE	14.8	**16.7**	**14.9**	**17.4**	13.5	13.8	15.5	14.1	**15.6**	14.5	14.1	11.2	**14.7**
REEDER	15.0	**16.0**	14.7	16.3	13.8	**13.9**	15.5	13.6	15.4	15.2	14.2	11.7	14.6
CORBIN	14.5	**16.7**	14.3	**16.9**	13.7	13.8	14.9	14.0	**15.8**	14.6	14.4	10.9	14.5
DUCLAIR	14.6	**16.6**	14.3	16.4	14.2	13.6	14.8	14.0	**16.1**	14.3	14.0	11.1	14.5
MT 2049	14.7	15.4	**14.9**	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	**16.3**	14.4	15.9	13.5	**13.9**	15.0	13.0	**15.5**	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	**16.1**	14.1	15.9	13.9	13.5	15.3	13.8	15.1	14.5	13.9	11.2	14.3
MT 2050	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	**16.0**	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	**16.8**	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
Mean (n=32)	**14.8**	**16.0**	**14.6**	**16.2**	**13.8**	**13.7**	**15.1**	**13.7**	**15.4**	**14.7**	**14.1**	**11.3**	**14.5**
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	<0.05	<0.001	<0.001	ns	<0.001
LSD (0.05)	**0.6**	**0.8**	**0.8**	**1.1**	**-**	**0.7**	**0.6**	**1.0**	**0.9**	**0.6**	**0.7**	**-**	**0.3**

Table 4. Agronomic trait comparisons between MT2049 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 MT2049, 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 Tolearnce
Environments	32	22	7	30	Bozeman (21-23)	Fort Benton (21-22)	Havre (21-22)	Rockford, WA (21-22)
MT 2049	59.6	**174.3**	**206.4**	27.9	11.0	65.9	43.0	MT
AP SMITH	60.2	178.1	208.0	26.1	10.2	67.6	41.2	S
CORBIN	60.1	175.3	**206.7**	29.1	12.6	**24.7**	**6.5**	T
DAGMAR	60.7	174.9	207.3	30.0	17.4	**23.9**	**2.7**	S
DUCLAIR	59.2	175.1	**205.4**	29.3	19.3	**19.8**	**3.9**	T
LANNING	59.7	175.9	**206.6**	28.3	7.7	74.3	51.0	T
LCS ASCENT	61.4	**174.4**	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 2050	59.7	176.7	207.9	29.1	19.0	**24.2**	**12.5**	S
MT CARLSON	60.0	176.0	**206.2**	28.7	18.1	**26.4**	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	**18.1**	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	**23.9**	**11.5**	S
SY INGMAR	60.5	177.9	207.7	27.7	8.8	61.1	36.9	S
SY LONGMIRE	60.6	176.7	**206.6**	28.1	**20.6**	**27.2**	**14.0**	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	**26.7**	**14.6**	S
WB 9516	61.3	177.3	210.6	28.6	8.1	47.1	26.4	N/A
WB 9719	**62.1**	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	**22.1**	**3.4**	S
Mean (n=32)	**60.0**	**177.0**	**207.9**	**29.3**	**11.9**	**48.1**	**26.8**	
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	
LSD (0.05)	**0.5**	**0.6**	**1.5**	**0.8**	**2.2**	**23.4**	**18.2**	

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 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 Days)			Plant Height (Inches)			Sawfly Cutting (%)	Falling Number (seconds)		
No. of environments	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	**46.2**	101.0	**59.9**	59.8	**59.8**	59.8	14.1	14.2	14.2	168.5	165.7	167.4	27.1	34.3	28.9	**12.7**	418	375	413
MT 2030	**45.5**	**101.7**	**59.6**	59.9	**59.8**	59.9	14.1	14.6	14.2	168.0	167.4	167.7	27.3	34.7	29.2	**27.5**	441	**409**	**437**
DAGMAR	**45.0**	**101.7**	**59.1**	60.5	**59.7**	60.3	14.6	14.8	14.7	**166.5**	**163.5**	**165.3**	**28.5**	35.4	30.2	**12.6**	432	363	424
MT DUTTON	**44.2**	99.5	**58.0**	59.0	59.2	59.1	14.6	14.5	14.6	168.6	166.9	167.9	27.8	35.3	29.7	**25.2**	432	348	423
VIDA	43.5	97.2	**57.0**	59.6	59.0	59.4	14.1	14.4	14.2	169.9	167.3	168.9	**28.3**	35.5	30.1	**19.7**	405	348	398
MT 2049	**44.0**	95.7	**56.9**	59.8	**59.6**	59.8	14.0	14.6	14.2	**166.0**	**164.5**	**165.4**	27.5	33.3	28.9	34.1	424	355	416
MT SIDNEY	43.2	97.7	**56.9**	60.4	**60.1**	60.3	14.3	14.2	14.3	168.1	165.8	167.2	27.9	34.3	29.5	28.6	421	357	414
MT 2050	42.7	99.2	**56.8**	59.6	**59.6**	59.6	14.1	14.2	14.1	168.9	166.6	168.0	27.5	35.4	29.5	**14.0**	413	379	409
LANNING	43.0	94.3	**55.8**	59.0	**59.5**	59.1	14.8	14.8	**14.8**	**166.8**	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	**12.3**	397	357	392
WB9879CLP	41.6	94.9	54.9	59.6	**59.6**	59.6	14.7	14.6	14.7	170.5	167.7	169.4	27.1	34.9	29.1	**5.6**	430	385	425
REEDER	40.6	95.5	54.3	59.9	**59.9**	59.9	14.6	**14.9**	14.7	168.5	167.1	167.9	**28.8**	**38.7**	**31.3**	31.8	410	358	405
SY INGMAR	39.3	96.3	53.5	60.1	**60.4**	60.1	**15.0**	14.7	**14.9**	169.9	168.3	169.2	26.7	33.4	28.3	28.5	**467**	354	**455**
SY SOREN	40.3	91.9	53.2	59.9	**60.3**	60.0	**15.1**	14.6	**15.0**	169.1	166.3	168.0	26.4	32.8	28.0	**25.8**	**459**	359	**448**
BRENNAN	40.1	91.9	53.1	**61.3**	**60.2**	**61.0**	14.9	14.7	**14.9**	**167.5**	165.6	166.7	26.0	31.9	27.5	**27.6**	**452**	376	**444**
Mean (n=17)	**42.7**	**96.6**	**56.2**	**59.8**	**59.6**	**59.7**	**14.5**	**14.5**	**14.5**	**168.5**	**166.5**	**167.7**	**27.6**	**34.7**	**29.3**	**22.5**	**424**	**364**	**417**
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
LSD (0.05)	**2.4**	**-**	**4.4**	**0.5**	**1.2**	**0.6**	**0.2**	**-**	**0.3**	**1.6**	**1.9**	**1.2**	**0.7**	**1.4**	**0.8**	**11.7**	**17**	**-**	**20**

Table 6. 2021 Fungal leaf spot evaluation of MT2049 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 2049	1	3.5	3.5	1.5
MT 2030	0	4	4	2
MT 2050	0	3.5	2	3
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

[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 MT2049 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[a]	% Incidence[b]	Disease Index[c]	% FDK[d]	DON (ppm)
			2021		
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
MT 2050	28.2 A	65.6 AB	18.4 AB	0.3 B	0.4
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
Mean	14.7	52	8.6	2.2	0.8
***P* value**	<0.0001	0.001	<0.0001	<0.0001	0.068
HSD (0.05)	10.4	28.5	9.6	5.9	n/a
			2022		
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
MT 2050	57.2 A-C	98.9	56.6 A-C	63.3	43.4 A
Mean	45.8	96	44.4	49.1	23.1
***P* value**	0.0027	0.3411	0.0038	0.2914	0.0039
HSD (0.05)	29.5	n/a	32.2	n/a	31.1
			2023		
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
MT 2050	43.7	84.4 A-C	38.0 A-C	33.3 A-C	11.0 CD
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
Mean	52.5	79.6	65.4	29.1	10.2
***P* value**	<0.0001	0.1078	<0.0001	0.0012	<0.0001
HSD (0.05)	28.6	n/a	33.2	25.7	6.9

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.

[b]Incidence: Percent of thirty plants per plot that had visible FHB symptoms.

[c]Disease Index is calculated as (Severity X Incidence)/100

[d]Fusarium damaged kernels

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

	Spillman, WA				Polouse, WA		Mount Vernon, WA					
Observation Date	7/3		7/12		7/3		6/7		6/27			
Growth Stage	Fks 11.1		Fks 11.2		Fks 11.1		Fks 4		Fks 10.54			Overall
Name	IT	%	IT	%	IT	%	IT	%	IT	%	Summary[c]	rating[d]
MT2049	2	5	8	20	8	50	8	80	8	90	S	9
MT2030	2	5	2	5	8	90	8	80	8	90	S	9
MT2050	2	5	3	10	2	20	3	40	5	40	MR	4
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

[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.

[c] R = resistant, MR = moderately resistant, MS = moderately susceptible, and S =susceptible.

[d] 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	Mixo mixing time (min.)	Mixo water absorption (%)	Bake mix time (min.)	Bake water absorption (%)	Loaf volume (cc)
WB 9719	70.2	13.5	**3.9**	5.6	**69.7**	13.3	79.3	1067
WB GUNNISON	68.0	12.6	**3.8**	**7.6**	67.1	**15.4**	78.2	1133
MCNEAL	68.4	13.7	**3.6**	**7.2**	**70.6**	14.2	**80.0**	**1190**
SY Longmire	69.9	13.7	**3.6**	5.3	**69.5**	11.7	**79.5**	**1187**
AP Smith	70.1	**14.0**	**3.5**	**7.4**	**71.6**	**17.9**	**81.8**	1079
ROCKER	69.1	**13.9**	**3.5**	6.3	**70.1**	13.1	**80.4**	**1198**
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	**1163**
SY INGMAR	70.5	**14.3**	3.4	6.0	**71.1**	14.6	**80.2**	**1207**
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	**14.0**	2.8	4.0	68.7	9.4	78.6	**1171**
MT CARLSON	68.9	13.4	2.8	3.6	67.7	8.1	77.2	1128
MT 2030	**71.4**	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	**71.7**	13.5	2.3	4.2	68.1	11.2	77.3	1116
MT 2050	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	**71.7**	12.9	1.5	3.5	67.2	7.9	76.6	1133
MEAN (n=32)	**69.9**	**13.5**	**2.9**	**4.7**	**68.4**	**10.3**	**77.9**	**1117**
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
LSD	**1.1**	**0.6**	**0.7**	**1.3**	**2.2**	**2.7**	**2.4**	**69**