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MEMORANDUM

FROM: Arpit Gaur, Ronald Proctor, Andrew Lehnerz, Ronald Ramsfield and Suchismita Mondal, Winter Wheat Breeders

DATE: January 29th, 2025

RE: Proposal for public cultivar release of MTV2164

Pedigree: MTV2164 is a selection from a cross of MT1265*2/Joe

Recommendation: Public, protected **Name:** To be determined

Contributors:

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Selection history: MTV 2164 is a hard red winter wheat line developed from a cross of MT1265*2/Joe. ‘Joe’ is a white grained, medium-late maturity, medium-tall variety from Kansas which has moderate resistance to stripe rust and carries the *WSM2* gene for resistance to Wheat streak mosaic virus (WSMV). MT 1265 is a hollow hard red winter wheat advanced lines from the breeding program which carries resistance genes for wheat curl mite. The table below follows the cross and advancement of the line

2016	Cross conducted in greenhouse between MT1265 and Joe
2017	F1 backcrossed to MT1265 (line named 17x6)
2017-2018	Sent for Double Haploid production to Heartland Plant Innovations, Kan. Lines were received at the end of 2018 and increased in greenhouse.
2019	Double haploids from the cross 17x6 were grown in field for observation and seed increase
2020	Selected line 17x6-DH-13 was included as part WSMV trial (Graduate Student Research study)
2021	MT2164 tested in multi-location preliminary yield trial, evaluated in WSMV nursery at Bozeman
2022	MT2164 tested in multi-location advanced yield trial
2023	MT2164 tested in multi-location Intrastate and Off-station yield trial
2024	MTV2164 tested in multi-location Intrastate and Off-station yield trial

General performance and characteristic:

MTV2164 is an awned, hollow, early heading, medium maturing, tall hard red winter wheat variety. It was developed through the double haploid pipeline with primary objective of integrating wheat streak mosaic virus resistance. Days to heading for MTV2164 on an average was two days earlier than check varieties Yellowstone, Warhorse, and Bobcat across years and locations of evaluations (Table1,2 &3). Plant height is like Yellowstone and about two inches taller than Warhorse. No lodging observed in multiple years of testing (specifically 2022 Bozeman, when lodging was a major issue across the yield trial plots). Winter survival was rated as 90% in 2023 and 2024 at Sidney, MT.

In 33 location-years of grain yield evaluations in the Advanced, Intrastate, Off-station yield trials conducted across location in Montana the average yield of MTV2164 has been around 4-7% higher compared to Warhorse. MTV2164 performed well across all locations in the Advanced yield trial conducted in 2022 (Table1). It was evaluated in the Intrastate trial for two successive year, 2023 and 2024, and continued to perform at par with the currently growing varieties with significantly higher yield across locations (Table 2). MTV2164 was also evaluated in 2023 and 2024 Off station trials conducted by the Montana Agricultural Experiment Stations in producers' fields. It had significantly high grain yields in most locations as well as across locations (Table 3)

Across all trial years the test weight of MTV2164 ranged between 58.6-60.1 (lb/bu) which was similar to Warhorse or Bobcat though lower than Brawl Cl Plus (Table1, 2 & 3). MTV2164 had average protein content across the location years tested. The mill and bake data from 2022 and 2023 indicate that MTV2164 has low ash content, average mix times and loaf volumes (Table 4).

MTV2164 was evaluated for wheat streak mosaic virus (WSMV) resistance in 2023 and 2024 in Kansas and showed moderate resistance to WSMV. Marker data confirms that MTV2164 has *WSMV2* gene which provides moderate resistance. The initial selection of the line was from a graduate student project. The disease rating data from Bozeman is not included as it was taken too late in the season.

MTV2164 was also characterized for stripe rust resistance at Washington State University (Pullman, WA, Table5)) and for stem rust at the USDA Cereal Disease Laboratory (St. Paul, MN). In 2024, very good natural stripe rust infection was observed at Sidney, MT and MTV2164 did not show any incidence of stripe rust infection (Table5). MTV2164 has good stripe rust resistance in multiple years and locations of evaluations. MTV2164 is highly susceptible to leaf rust and stem rust (2024 NRPN and CDL evaluations).

Purification/ Seed stock: Increase of MTV2164 was initiated in 2022 when 140 individual heads were collected from a phenotypically uniform plot. Multiplication and purification plots were grown at Post Farm in 2023. Selected uniform rows were bulked and sown at Post Farm for Breeder's seed increase in 2024. Breeder seed of MTV2164 was planted in Fall 2024 at Lutz Farm for Foundation seed production in 2025

Summary: MTV2164 is a high yielding, tall, hollow stem line that carries the *WSM2* gene and shows moderate resistance to wheat streak mosaic virus. MTV2164 has stable yield performance across the testing locations. Being a hollow stem line, it is susceptible to wheat stem sawfly cutting. It has moderate resistance to stripe rust though susceptible to stem and leaf rust. MTV2164 combines high yield with moderate resistance to wheat streak mosaic virus and strip rust.

Figure 1. Grain yield and agronomic performance of MTV2164 and check varieties in 2022 Advanced Yield Trial across six locations in Montana.

Variety/Line	Grain Yield (bu/ac)						Across Locations					
	Bozeman	Havre ¹	Williston	Moccasin	Huntley	Ft Benton	Combined Yield (bu/ac)	Test Weight (lb/bu)	Heading date (Julian)	Plant Height (in)	Sawfly Cutting (%)	Protein (%)
Locations(n)							n=6	n=6	n=6	n=6	n=2	n=4
Yellowstone	111.0	57.2	19.3	41.5	38.5	32.2	50.0	57.9	171	29.6	55.7	13.4
Warhorse	107.6	51.7	21.1	37.8	44.3	31.6	49.3	58.6	170	27.9	9.3	14.1
SY Monument	127.2	49.9	24.3	41.0	46.2	30.9	53.1	57.9	168	27.6	44.6	13.1
Bobcat	103.8	62.0	22.5	44.0	48.4	34.2	52.9	59.2	170	26.4	3.9	13.7
MTV2164	130.9	55.6	22.8	41.3	39.0	34.3	51.1	58.6	169	29.9	57.4	13.7
Mean (n=36)	113.4	55.9	19.9	37.3	44.4	31.9	50.4	58.0	169.6	27.9	36.2	13.7
LSD (0.05)	10.7	3.4	4.4	5.7	4.6	8.8	2.6	1.0	1.0	0.9	23.3	0.8
C.V. (%)	7.1	3.9	18.5	11.1	6.8	14.2	9.3	1.6	0.6	4.3	38.4	4.6
Gen significance	<0.001	<.0001	0.01	0.001	<0.0001	0.0017	<.0001	<.0001	<.0001	<.0001	0.0002	.0004

***BOLD** data values indicate significantly different

¹ Havre had high sawfly infestation in 2022

Figure 2. Grain yield (bu/ac) and agronomic performance of MTV2164 and check varieties in 2023 and 2024 Intrastate trials.

Varieties/lines	Grain Yield (2023-2024, bu/ac)								Across Locations (2023-2024)					
	Bozeman	Ft Benton	Havre	Huntley	Kalispell	Moccasin (2024)	Sidney	Williston (2023)	Grain Yield (bu/ac)	Days to Heading (Julian)	Plant Height (in)	Test Weight (lb/bu)	Protein (%)	WSMV rating (Kansas)
Locations years (n)									n=14	n=12	n=12	n=10	n=11	n=2
Warhorse	100.2	54.3	50.0	62.6	143.5	39.9	89.6	47.7	81.2	162.7	31.3	61.6	12.2	
Yellowstone	112.4	42.0	63.2	52.8	168.5	38.8	103.7	48.6	84.2	162.6	33.2	60.8	11.9	
Bobcat	104.3	45.3	58.9	46.8	164.2	35.4	94.3	50.5	82.9	162.1	28.9	61.5	12.1	
Flathead	97.8	52.8	60.3	54.1	174.5	39.0	98.5	50.4	84.0	158.1	31.3	61.7	11.8	
FourOSix	118.7	51.3	60.5	47.6	172.8	37.7	100.6	52.8	85.3	161.5	30.9	61.2	11.9	
MTV2164	116.6	54.0	65.1	60.6	179.1	38.8	104.0	54.9	87.6	160.6	33.5	60.9	11.9	5.5
Mean (n=49)	105.4	55.8	59.5	57.3	160.1	36.1	96.7	48.1	85.0	161.3	31.1	61.3	11.9	
LSD (0.05)	21.2	21.5	13.4	33.5	33.7	10.0	13.1	6.5	6.1	0.9	0.9	0.6	0.35	
CV (%)	7.3	18.8	8.3	9.6	14.5	16.2	5.4	8.3	13.8	0.73	0.7	0.9	4.2	
Gen significance	0.001	0.01	0.02	0.25	0.001	0.001	0.001	0.01	<0.001	<0.001	<0.001	0.008	<0.001	

***BOLD** data values indicate significantly different statistically

Figure 3. Grain yield (bu/ac) and agronomic performance of MTV2164 and check varieties in Off-Station Yield Trial conducted across seven locations in Montana in 2023 and 2024.

Variety/Line	Grain Yield (2023-2024, bu/ac)							Across Locations years			
	Loma	Loring	Huntley Irrigated	Hysham	Molt	Repelje	Flycreek	GrainYield (bu/ac)	TestWeight (lb/bu)	Sawfly(%)	Protein(%)
Locations							(2024)	n=13	n=13	n=4	n=13
Yellowstone	69.1	58.5	93.5	73.5	68.6	79.1	80.4	73.6	59.5	43.3	12.6
Warhorse	61.8	48.2	99.2	69.2	78.5	75.2	74.2	70.2	59.7	12.2	13.3
Bobcat	69.6	56.3	104.1	79.4	71.1	73.9	71.6	74.9	60.2	5.2	12.9
BrawlCLPlus	65.7	48.5	99.8	74.5	68.6	62.5	74.4	69.3	61.2	32.1	13.0
Flathead	68.6	55.5	98.6	65.9	70.1	70.4	91.0	71.1	60.7	38.3	12.7
FourOSix	63.9	44.9	96.2	74.2	73.7	77.9	84.9	70.0	59.9	41.6	12.7
MTV2164	68.7	58.3	102.5	76.4	82.2	79.7	91.9	76.1	60.1	35.3	12.7
Mean	67.0	51.7	100.8	74.2	77.9	76.2	86.4	73.5	60.1	32.2	12.8
LSD (0.05)	2.6	18.3	12.2	22.9	6.4	11.1	12.4	5.2	0.6	14.4	0.3
CV (%)	8.5	13.1	9.3	10.8	10.6	8.5	12.1	10.1	1.3	34.0	3.5
Gen. Significance	0.003	0.00	0.03	NS	0.04	0.01	0.03	0.01	<0.001	0.004	<0.001

*BOLD data values indicate significantly different statistically

Table 4. Quality analysis of MTV2164 and check varieties across three locations between 2022-2023.

Variety/Line	PPO	Single Kernel Hardness	Wheat protein, % (12 m.b.)	Flour Yield %	Flour Protein%(14%m.b)	Wheat Ash, %	Flour Ash, %	Mixograph			Test Bake		
								Tolerance	Mixing Time Min	Water Absorption%	Mixing Time Min	Water Absorption%	Loaf Volume
Yellowstone	0.239	69.2	13.6	68.9	12.4	1.61	0.46	3.8	8.1	64.8	14.6	75.2	1000
Warhorse	0.267	81.6	14.2	67.7	13.3	1.54	0.46	2.2	4.2	64.2	7.5	73.8	1075
Bobcat	0.262	67.5	13.9	70.1	13.1	1.56	0.42	3.7	5.7	64.4	13.1	75.2	1072
MTV2164	0.282	67.9	13.7	69.3	12.5	1.44	0.43	3.8	5.7	63.4	13.1	75.1	1001
Grand Mean	0.224	71.5	13.7	69.8	12.6	1.52	0.44	3.4	6.82	64.5	13.8	74.9	1047
LSD	0.06	8.7	0.8	1.5	0.75	0.24	0.02	0.97	4.0	1.5	5.3	3.6	76.7
CV	14.9	7.7	3.3	0.94	3.69	8.77	2.95	23.8	43.6	3.6	28.5	2.9	4.17
Gen significance	<0.001	0.03	0.005	0.04	0.01	0.60	<0.001	0.02	0.04	ns	<0.001	0.08	0.02

***BOLD** data values indicate significantly different statistically

Table 5. Stripe rust infection type (It ^{a,b}) an severity (%) of MTV2164 and check varieties in 2022 and 2023 at Pullman, Mt Vernon and Central Ferry in Washington and severity (%) in 2024 at Sidney, MT.

Varieties/Lines	2022								2023								2024
	Pullman		Mt. Vernon				Central Ferry		Pullman				Mt. Vernon				Sidney, MT
	24-Jun		13-Apr		19-May		23-Jun		16-Jun		22-Jun		27-Apr		6-Jun		27-Jun
	IT	%	IT	%	IT	%	IT	%	IT	%	IT	%	IT	%	IT	%	%
Yellowstone	2	15	2	5	2	20	5	30	5	10	3	20	3	30	2	10	30
Warhorse	2	10	2	5	2	10	2	5	5	15	2	5	5	50	2	10	5
Bobcat	3	15	5	10	2	10	2	5	3	5	2	5	2	20	2	10	7
Flathead	2	5	2	5	2	5	3	20	3	5	3	5	2	5	2	10	0
FourOSix	2	15	2	5	2	20	3	20	3	5	3	10	2	20	2	10	10
MTV2164	2	5	2	5	2	10	2	40	3	10	3	20	2	10	3	10	0

^aInfection Type (IT) was recorded based on the 0-9 scale with ITs 8 and 9 combined as 8 (the most susceptible reaction) in field. Generally, IT 0-3 are considered resistant, 4-6 intermediate and 7-9 susceptible

^bEntries with a high IT in the first note, but a low IT in the second note may indicate that they have high-temperature adult plant (HTAP) resistance