MONTANA STATE UNIVERSITY

MEMORANDUM

FROM: Michael J. Giroux and Andrew C. Hogg

DATE: 2/5/2026

RE: Motion for Release of MTD19011 spring durum wheat with supporting documentation.

RECOMMENDATION Public, protected **NAME** To be determined

CONTRIBUTORS

- Dr. Mike Giroux and Mr. Andy Hogg, MSU Bozeman, MT
- Dr. Pat Carr and Dr. Jed Eberly, MSU-CARC, Moccasin, MT
- Dr. Chengci Chen, Ms. Calla Kowatch-Carlson and Dr. Frankie Crutcher, MSU-EARC, Sidney, MT
- Ms. Peggy Lamb MSU-NARC, Havre, MT
- Mr. Doug Holen, MSU Foundation Seed, Bozeman, MT
- Dr. Linda Dykes, USDA-ARS, Fargo, ND
- Dr. Xianming Chen USDA-ARS, Pullman, WA
- Dr. Li Huang, MSU, Bozeman, MT
- Dr. Zhaohui Liu, NDSU, Fargo, ND

SEED AVAILABILITY

Breeder's seed ($F_{5:12}$) was planted spring 2025 in Bozeman, MT and approximately 20 bushels was harvested by MSU Foundation Seed. Seed harvested will be replanted as Foundation seed in Bozeman, MT Spring 2026, followed by registered seed in 2027 and certified seed in 2028.

Crop Science

Entomology

Horticulture

Plant Biology

Plant Genetics

Plant Pathology

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PEDIGREE

Alkabo/Brigade//AAC Durafield

- **'Alkabo'- North Dakota State University, 2005**

  'Alkabo' was tested as experimental line D96604 selected from the cross D901247/D89263 made in 1992. Alkabo is high yielding and has moderate protein strength and normal cadmium content. The parent D901247 was derived from the cross D81154/'Renville' (PI 510696)/LDN(Dic-5B). The pedigree of D81154 is PI19571/'Ward'(CI 15892). LDN(Dic-5B) is a substitution line of 'Langdon' (CI 13165) with chromosome 5B of *Triticum dicoccoides* accession FA-15-3 (Joppa and Cantrell, 1990). D89263 was derived from the cross 'Fjord'/D8194.

  Elias, E.M. and Manthey F.A. Registration of 'Alkabo' Durum Wheat. 2007. Journal of Plant Registrations, 1:10-11. https://doi.org/10.3198/jpr2006.05.0279crc

- **'Brigade'- Agriculture and Agri-Food Canada (AAC), 2008**

  'Brigade' was selected from the cross DT513/DT696 made in 1999. Brigade has good yield, high gluten strength, good straw strength and fusarium resistance better than many Canadian durum varieties and carries the low cadmium trait. DT513 (DT625/DT612) was developed at the Crop Development Centre, University of Saskatchewan, and DT696 (DT618/DT 637//Kyle) derives from the AAC breeding program.

  Clarke, J.M., Knox, R.E., DePauw, R.M., Clarke, F.R., Fernandez, M.R., McCaig, T.N., Singh, A.K. 2009. Brigade Durum Wheat. Canadian Journal of Plant Science, 89(3) https://doi.org/10.4141/CJPS08168

- **'AAC Durafield- Agriculture and Agri-Food Canada (AAC), 2014**

  AAC Durafield (experimental names: DT832, A0345&BV022) was selected from the cross DT749/DT735//Strongfield made in 2003 at the Semiarid Prairie Agricultural Research Centre (SPARC), Swift Current, SK. DT749 (A9822-LH1) is a breeding line derived from a cross of AC Avonlea/Napoleon. DT735 (9781-BW5) is a breeding line derived from a cross of DT696/AC Avonlea. AC Avonlea (Clarke et al. 1998), Napoleon (Humphreys et al. 2010), and Strongfield (Clarke et al. 2005b) are Canadian durum cultivars. DT832 was developed through the doubled haploid (DH) technique at SPARC-Agriculture and Agri-Food Canda using wheat-maize pollen system (Knox et al. 2000).

A.K.Singh, R.M.DePauw, R.E.Knox, J.M.Clarke, T.N.McCaig, R.D.Cuthbert, and Y.Ruan. 2016. AAC Durafield durum wheat. *Canadian Journal of Plant Science*. 96(4): 719-725. https://doi.org/10.1139/cjps-2015-0262

SELECTION AND TESTING HISTORY

MTD19011 is derived from crosses between the cultivars Alkabo, Brigade and AAC Durafield. In 2015, Alkabo was crossed to Brigade and resulting F_1 seed was saved. In 2017, an F_1 Alkabo/Brigade plant was crossed to AAC Durafield. The F_1 from this cross was then advanced to the F_5 generation by single seed descent at which point a whole head was harvested. In 2019, 147 Alkabo/Brigade//AAC Durafield $F_{5:6}$ lines were planted in head-rows (~20 seeds/1.5 m row) in Bozeman, MT at the Post Agronomy Farm and rows were visually selected and threshed using a Vogel thresher. Traits taken into consideration were tillering, straw strength, height, disease reactions, head size/shape, overall vigor, and maturity. Harvested grain was assessed for protein content and lines with protein below 13.5% were discarded.

In 2020, MTD19011 was included in the durum irrigated preliminary yield trial (PYT) grown in Bozeman, MT at the Post Agronomy Farm which consisted of 370 $F_{5:7}$ entries. Entries and check cultivars Mountrail, Divide, Joppa, Tioga, ND Riveland and ND Grano were grown in 0.6 m x 3.3 m plots using a randomized complete block design with two replicates. Entries were evaluated for yield, test weight, and protein and plots were harvested with a plot combine. All 370 ($F_{5:8}$) entries and check cultivars were re-evaluated in 2021 in the durum irrigated PYT grown in Bozeman, MT at the Post Agronomy Farm. Entries were grown in 0.6 m x 3.3 m plots in a randomized complete block design with three replicates and were evaluated for plant height, heading data, yield, test weight, and protein. Seed was also planted in the greenhouse and five plants per genotype were bulked together for DNA extraction and marker evaluation. Seed from this trial was milled at MSU in the Cereal Quality Lab and semolina was evaluated for yield, color, and gluten index. Based on yield, test weight, and protein results from 2020/2021 trials, 2021 quality results, and 2021 height and flowering results, MTD19011 was selected for advancement to the statewide durum advanced yield trials.

In 2022, MTD19011 ($F_{5:9}$) was grown at seven MAES on-station locations across the state to evaluate agronomics and seed from these trials was sent to the USDA quality lab in Fargo, ND for quality testing. Locations tested in 2022 were Bozeman Post Agronomy Farm (irrigated and dryland), CARC (dryland), EARC (irrigated, dryland), NARC (dryland), and WTARC (dryland). In 2023, MTD19011 ($F_{6:10}$) was tested at eight MAES on-station locations: Bozeman Post Agronomy Farm (two dryland sites), CARC (dryland), EARC (dryland, irrigated, re-crop), NARC (dryland), and WTARC (dryland). Seed samples harvested from these locations were sent for quality analysis except for the EARC re-crop. MTD19011

was also tested at six off-station locations in Valier, Loring, Turner, Chester, Sheridan Co., and Roosevelt Co., MT. Yield and quality data from NARC and WTARC on-station locations were lost due to harvest errors. In 2024, MTD19011 ($F_{5:10}$) was planted at seven MAES on-station locations: Bozeman Post Farm (irrigated and dryland), CARC (dryland), EARC (irrigated and dryland), NARC (dryland) and WTARC (dryland). Seed harvested from these locations was sent for quality analysis. Yield data from CARC and Bozeman Post Farm dryland was impacted by hail damage and not used in yield analysis. MTD19011 was also tested in 2024 at eight off-station trials: Conrad, Loring, Chester, Turner, McCone Co., Roosevelt Co., Sheridan Co., and Valley Co., MT. In 2025, MTD19011 ($F_{5:11}$) was tested at six MAES on-station locations: Bozeman (irrigated and dryland), CARC (dryland), EARC (irrigated and dryland), and NARC (dryland). Seed from these locations was sent for quality analysis. MTD19011 was also tested at seven off-station locations in 2025: Turner, Chester, Loring, Wibaux Co., Sheridan Co., Valley Co., McCone Co., Valier, and Choteau, MT. Agronomic data from the location in Turner, MT was lost due to hail damage.

PURIFICATION OF SEED STOCK

MTD19011 was developed using the single seed descent method F_1-F_5 from 2017-2019. A single F_5 head was harvested from the greenhouse and $F_{5:6}$ seed was planted in a head-row in spring 2019. In fall 2019, a single $F_{5:6}$ head-row was selected and harvested by binder and threshed with a Vogel for seed stock. In 2020, a plot (0.6 m x 3.3 m) of MTD19011 ($F_{5:7}$) was planted in a preliminary yield trial (PYT) in Bozeman, MT and harvested using a plot combine. In 2021, a plot (0.6 m x 3.3 m) of MTD19011 ($F_{5:8}$) was planted using seed from the 2020 Bozeman PYT in Bozeman, MT and seed was harvested using a plot combine. In 2022, increase plots (1.2 m x 10 m) of MTD19011 ($F_{5:9}$) were planted in Bozeman, MT using the seed from the 2021 Bozeman PYT. Plots were rogued twice during the season to remove contaminants and harvested with a plot combine. In 2023, increase plots (1.2 m x 10 m) of MTD19011 ($F_{5:10}$) were planted from the 2022 increase and rogued twice during the growing season, then 217 representative heads were collected for line-row purification the following year. In 2024, 217 MTD19011 ($F_{5:11}$) line-rows were planted in 3.3 m rows and harvested in bulk using a clean plot combine. Non-uniform line-rows based on height, head type, and maturity were discarded before harvest. In 2025, seed from purified MTD19011 line-rows was used to plant 0.2 ha of breeders seed increase ($F_{5:12}$). Approximately 20 bushels of MTD19011 breeder's seed was harvested in the fall of 2025.

AGRONOMIC CHARACTERISTICS

MTD19011 is a standard height, hollow stemmed spring durum wheat (*Triticum turgidum* ssp. *durum*) that is approximately 32.6 inches tall, 2 inches shorter than ND Riveland (34.4 in) and 4 inches taller than Alzada (27.4 in) (Table 1). MTD19011 has white glumes and awns and a heading date of June 29th, 3 days later than Alzada, and 1 day earlier than ND Riveland (Table 1). MTD19011 has a white coleoptile, dark green leaves with a waxy bottom, an erect growth habit, an erect flag leaf, a white auricle, no anthocyanin in the stem, and yellow anthers. Averaged over all locations and conditions (2022-2025, 41 location-years) MTD19011 (59.2 bu/ac) had significantly higher yield than all varieties tested except for MT Blackbeard (58.6 bu/ac). MTD19011 also had test weight (60.3 lbs/bu) that was statistically equal to MT Blackbeard (60.6 lbs/bu), ND Riveland (59.8 lbs/bu), Joppa (60.8 lbs/bu), and Alzada (59.8 lbs/bu) (Table 1). The protein content of MTD19011 (15.0 %) was equal to that of common grown varieties (Table 1). Averaged over dryland durum growing locations from North Central and Northeastern, MT (2022-25, 30 location-years) MTD19011 (45.2 bu/ac) was the highest yielding line compared to all other varieties tested except for Alzada (44.0 bu/ac), which yielded 1.2 bu/ac less (Table 2). In the North Central growing region (2022-2025, 16 location-years), where Alzada makes up 80% of the acreage, MTD19011 (40.4 bu/ac) yielded similar to Alzada (39.4 bu/ac), but statistically higher than all other varieties tested (Table 3). In the Northeastern region (2022-25, 18 location-years), where most of the durum is grown in the state, MTD19011 (62.1 bu/ac) was the highest yielding line overall but not statistically more than MT Blackbeard (61.0 bu/ac), Lustre (60.4 bu/ac), and Divide (60.4 bu/ac) (Table 4). From trials that had high sawfly cutting in North Central (Choteau) and Northeastern, MT (Wibaux, Roosevelt, and McCone Co.) in 2025, MTD19011 (27.9%) had a cutting percentage and stem solidness score (10) similar to other hollow stem durum lines like ND Riveland (20.7%, 9), Alzada (30.6%, 12) and MT Blackbeard (25.3%, 9), which was significantly higher than the solid stem control line AAC Stronghold (3.0%, 25) (Table 5).

QUALITY CHARACTERISTICS

Averaged over three years and all MAES on-station locations (2022-24, 20 location-years), MTD19011 had a grain protein content (14.4%), equal to common grown varieties such as Alzada (14.2%), Joppa (14.2%) and ND Riveland (14.5%) (Table 6). MTD19011 (40.2 mg) had a large individual seed weight, similar to Alzada (41.2 mg), MT Blackbeard (41.0 mg) and ND Riveland (40.1 mg) and a high percentage of large seeds (53.6%), though not as high as Alzada (64.5%) and MT Blackbeard (65.5%) (Table 6). The test weight of MTD19011 (60.2 lbs/bu) was similar to the other varieties tested except for MT Raska (61.6 lbs/bu) which was 1.4 lbs/bu higher (Table 6). MTD19011 (475.4 sec) had a falling number that was similar to ND Riveland (472.8 sec) and MT Blackbeard (478.8 sec) but higher than Joppa (438.4

sec), Divide (436.6 sec), MT Raska (450.3 sec) and Mountrail (436.8 sec) (Table 6). After milling using a Quadramat Jr. mill and sifting, MTD19011 had a high semolina yield (63.8%) similar to MT Raska (64.2%) and Alzada (63.8%) which was significantly higher than ND Riveland (60.4%) and WB8148 (62.6%) (Table 7). Semolina from MTD19011 had protein (13.0%) similar to the other varieties tested and an ash content (0.65%) that was similar to Divide (0.66%), Joppa (0.67%), and ND Riveland (0.66%) (Table 7). MTD19011 (30.7) had semolina with yellow color similar to Joppa (30.8), MT Blackbeard (30.6) and ND Riveland (30.5) but less than Alzada (31.5), WB8148 (31.6), and MTD19241 (31.9) (Table 7). MTD19011 had a gluten index (70.2) similar to MT Raska (77.6) and Divide (75.7) but less than Alzada (93.9), MT Blackbeard (93.8), WB8148 (92.6) and ND Riveland (86.6) and higher than Mountrail (23.9) (Table 7).

DISEASE EVALUATIONS

MTD19011 was found to be resistant to stem rust race TPMLK-61208 in greenhouse testing in 2026 (Table 8). Susceptibility to leaf spot caused by *Pyrenophora tritici-repentis* (Ptr) and *Stagnospora nodorum* (Sn) was evaluated in 2022-2024 in the greenhouse and MTD19011 was found to be ToxA sensitive, moderately resistant to the most prevalent race of Ptr in North Dakota with a 2.2 rating similar to MT Raska (1.8) and ND Riveland (2.4), and moderately susceptible to Sn with a rating of 3.3 similar to Joppa (3.2) and Lustre (3.0) (Table 9). MTD19011 was evaluated in the field for susceptibility to naturally occurring stripe rust in 2022-2025 near Pullman, WA and displayed moderate resistance with an infection type of 2.8 and a low percent infection of 15.0% similar to Divide (15.0%) and Alzada (17.5%) (Table 10). Fusarium head blight susceptibility was evaluated in 2022-2024 in the field at EARC in Sidney, MT. MTD19011 was found to be moderately susceptible and had a similar percent severity (37.6 %) as ND Riveland (31.7%), while it had the lowest percent of Fusarium damaged kernels (25%) and the lowest concentration of DON in the seeds (14.7 ppm) of all the varieties tested (Table 11).

KASP MARKERS

MTD19011 was tested with KASP markers for solid stem (usw275, Nilsen et al. 2020), cadmium accumulation (Cad-5B, Alsaleh et al. 2022) and Tsn1 ToxA sensitivity (FCP992, Running et al. 2025). MTD19011 and was found to carry the hollow stem allele, a low cadmium accumulation allele and the Tox A sensitive *Tsn1* allele.

Nilsen KT, Walkowiak S, Xiang D, Gao P, Quilichini TD, Willick IR, Byrns B, N'Diaye A, Ens J, Wiebe K, Ruan Y, Cuthbert RD, Craze M, Wallington EJ, Simmonds J, Uauy C, Datla R, Pozniak CJ. 2020. Copy number variation of *TdDof* controls solid-stemmed architecture in wheat. Proc Natl Acad Sci U S A.;117(46):28708-28718. https://doi.org/10.1073/pnas.2009418117.

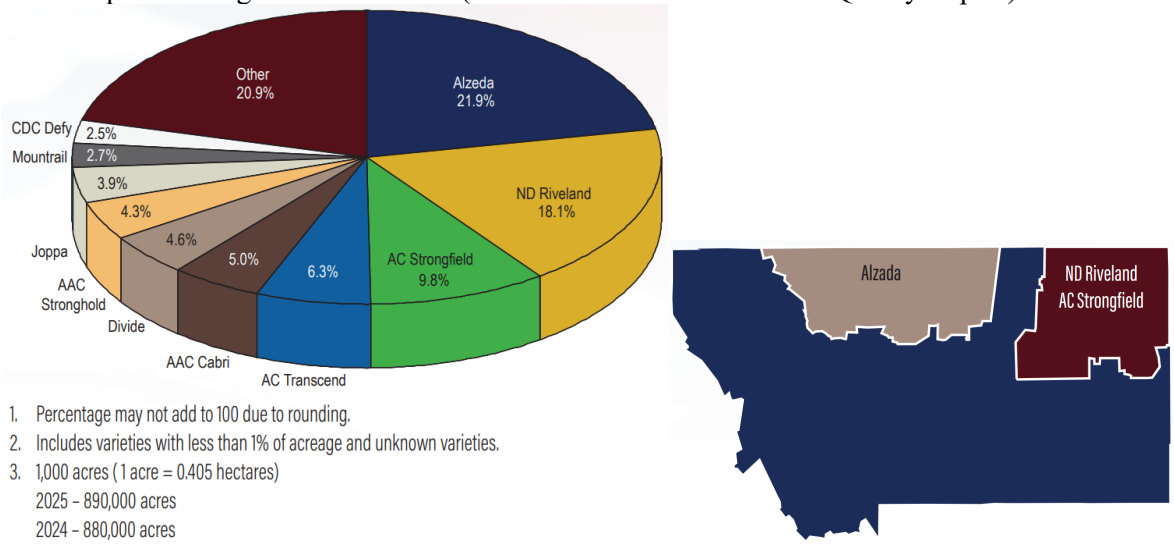
Running KLD, Acharya K, Roth TM, Singh G, Szabo-Hever A, Peters Haugrud AR, Fiedler JD, Friesen TL, Faris JD. 2025. Development of diagnostic markers for the disease susceptibility gene Tsn1 in wheat reveals novel resistance alleles and a new locus required for ToxA sensitivity. Theor Appl Genet. 138(7):164. https://doi.org/10.1007/s00122-025-04952-6.

Alsaleh A, Baloch FS, Sesiz U, Nadeem MA, Hatipoğlu R, Erbakan M, Özkan H. 2022. Marker-assisted selection and validation of DNA markers associated with cadmium content in durum wheat germplasm. *Crop & Pasture Science* 73, 943–956. https://doi.org/10.1071/CP21484

STATISTICAL ANALYSIS

For yield data across location-years, individual replications from each location-year were analyzed using PROC MIXED in SAS 9.4 where entries were considered a fixed effect and location-years and rep(location-year) were considered random effects. For stripe rust and fungal leaf spot year was considered a random effect. For Fusarium head blight year and rep(year) were considered random effects. Least significant differences were calculated using a two-tailed *t* test using the appropriate degrees of freedom and the standard error from the differences of least square means.

Figure 1. Top cultivars grown in Montana (source: 2025 Northern Durum Quality Report)

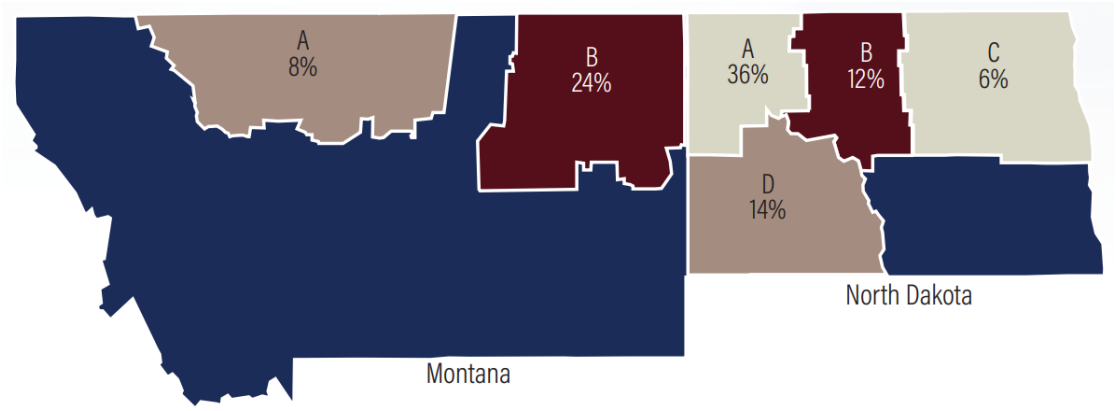


1. Percentage may not add to 100 due to rounding.
2. Includes varieties with less than 1% of acreage and unknown varieties.
3. 1,000 acres (1 acre = 0.405 hectares)
   2025 - 890,000 acres
   2024 - 880,000 acres

Figure 2. Approximate share of regional production (source: 2025 Northern Durum Quality Report).

2025 PRODUCTION DATA

	2025	2024	2020-24 AVERAGE
MILLION BUSHELS			
Montana	25.5	19.8	19.2
North Dakota	53.2	51.5	33.9
U.S. Total	86.2	80.1	61.5



MTD19011	MTD19241
Hollow stem	Solid stem
Mid yellow semolina (b*=30.7)	Highest yellow semolina (b*=31.9)
Lowest FDK and DON from FHB testing	Low FDK and DON from FHB testing
Larger seeds (40.2 mg)	Smaller seeds (35.1 mg)
31.4 in tall, heading date of 174.2	30.6 in tall, heading date of 173.6

MTD19011 Traits of Interest

- Highest yield potential of lines tested in durum growing areas
- Large kernel weight with average test weight and protein
- Standard plant height with medium heading date
- Good end-use qualities; good milling yield, low ash, average yellow semolina color, medium gluten strength
- Moderate resistance to stripe rust and leaf spot
- Moderate FHB susceptibility, lowest FDK and DON
- Low cadmium accumulation trait

Figure 3. Yield percent compared to Alzada in North Central Montana (16 location-years, 2022-2025).

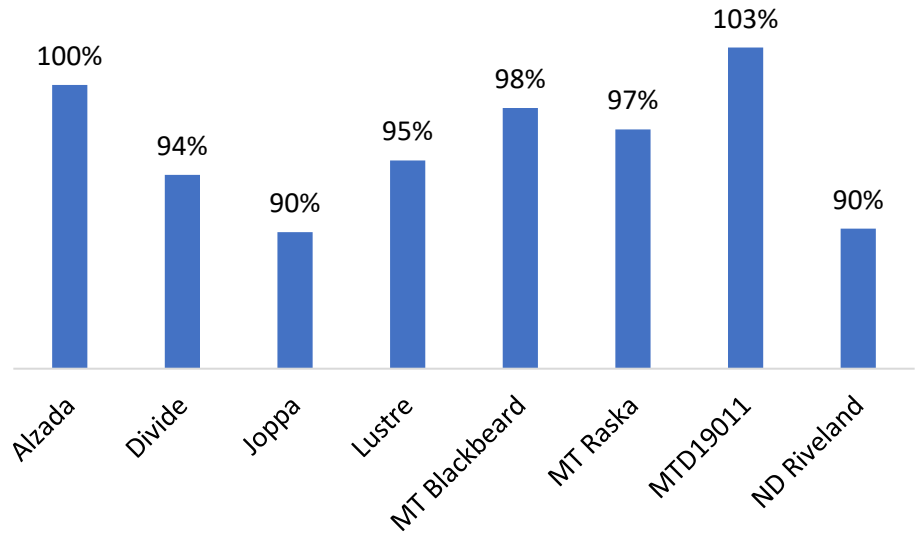


Figure 4. Yield percent compared to ND Riveland in Northeastern Montana (16 location-years, 2022-2025).

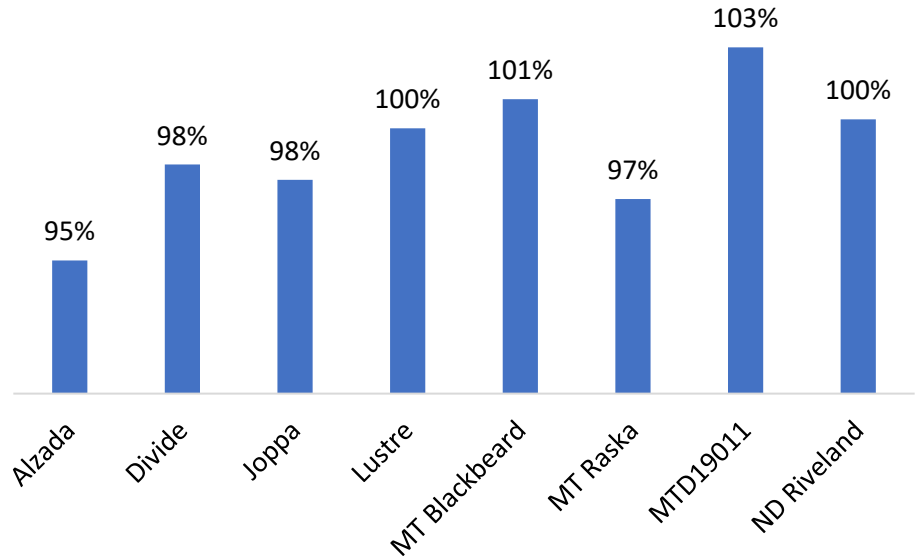


Table 1. Agronomic evaluation from all locations and environments from statewide durum advance yield trials (41 location-years, 2022-2025).

ID	Yield[1] (bu/ac)	Test weight (lbs/bu)	Protein[2] (%)	Plant Height (inches)	Heading date[3] (Julian)
Alzada	55.6	59.8	14.8	27.4	177.6
Divide	55.7	60.7	15.1	33.3	181.0
Joppa	55.6	60.8	15.0	33.0	180.5
Lustre	55.9	59.8	15.2	33.0	181.5
MT Blackbeard	**58.6**	60.6	15.1	**35.4**	**182.3**
MT Raska	56.2	**61.6**	15.1	25.5	177.6
MTD19011	**59.2**	60.3	15.0	32.6	180.4
ND Riveland	56.4	59.8	**15.8**	34.4	181.2
Mean	56.3	60.4	15.1	31.8	180.2
LSD (0.05)	1.8	0.5	0.4	0.5	0.4
Pr > F	<0.0001	<0.0001	0.0031	<0.0001	<0.0001

[1]Grain yield reported on a 13% moisture basis.
[2]Grain protein reported on a 12% moisture basis.
[3]n=20 location-years.
Bold and underline are highest value in column and bolded lines are statistically similar to highest value based off LSD (α=0.05).

Table 2. Agronomic evaluation from dryland durum growing regions from statewide durum advanced yield trials (North Central and Northeastern, MT 30 location-years, 2022-2025).

ID	Yield[1] (bu/ac)	Test weight (lbs/bu)	Protein[2] (%)	Plant Height (inches)	Heading date[3] (Julian)
Alzada	**44.0**	59.5	15.0	26.7	172.6
Divide	42.5	60.2	15.4	31.4	175.8
Joppa	40.6	60.2	15.4	30.9	175.7
Lustre	42.0	59.2	**15.6**	31.0	**176.4**
MT Blackbeard	43.5	60.0	15.5	**33.1**	**177.0**
MT Raska	43.3	**61.3**	15.5	24.7	172.6
MTD19011	**45.2**	59.9	15.4	30.5	175.3
ND Riveland	41.0	59.6	**15.8**	32.2	**176.4**
Mean	42.7	60.0	15.4	30.0	175.2
LSD (0.05)	1.3	0.2	0.2	0.5	0.6
Pr > F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1]Grain yield reported on a 13% moisture basis.
[2]Grain protein reported on a 12% moisture basis.
[3]n=9 location-years.
Bold and underline are highest value in column and bolded lines are statistically similar to highest value based off LSD (α=0.05).

Table 3. Agronomic evaluation from North Central, MT dryland locations from statewide durum advanced yield trials (16 location-years, 2022-2025).

ID	Yield[1] (bu/ac)	Test weight (lbs/bu)	Protein[2] (%)	Plant Height (inches)	Heading date[3] (Julian)
Alzada	**39.4**	57.9	15.2	26.5	175.3
Divide	36.9	58.1	15.6	29.9	178.0
Joppa	35.3	58.0	15.6	29.8	177.8
Lustre	37.3	57.2	15.8	29.7	**178.5**
MT Blackbeard	38.7	58.0	15.7	**31.4**	**179.2**
MT Raska	38.1	**59.5**	**15.8**	24.3	176.0
MTD19011	**40.4**	57.7	15.6	29.2	177.6
ND Riveland	35.4	57.3	**16.1**	**30.9**	**178.5**
Mean	37.7	58.0	15.7	29.0	177.6
LSD (0.05)	1.6	0.3	0.3	0.6	1.0
Pr > F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1]Grain yield reported on a 13% moisture basis.
[2]Grain protein reported on a 12% moisture basis.
[3]n= 4 location-years.
Bold and underline are highest value in column and bolded lines are statistically similar to highest value based off LSD (α=0.05).

Table 4. Agronomic evaluation from Northeastern, MT dryland and irrigated locations from statewide durum advanced yield trials (16 location-years, 2022-2025).

ID	Yield[1] (bu/ac)	Test weight (lbs/bu)	Protein[2] (%)	Plant Height (inches)	Heading date[3] (Julian)
Alzada	57.5	61.5	14.6	28.1	170.7
Divide	**60.4**	**63.0**	14.8	34.6	174.6
Joppa	59.3	**63.1**	14.7	33.9	174.1
Lustre	**60.4**	62.1	15.0	34.0	**175.2**
MT Blackbeard	**61.0**	**62.7**	14.8	**36.4**	**175.7**
MT Raska	58.9	**63.6**	14.8	26.1	170.3
MTD19011	**62.1**	**62.6**	14.7	33.4	173.9
ND Riveland	**60.1**	61.5	**16.0**	35.4	174.9
Mean	59.9	62.5	14.9	32.7	173.7
LSD (0.05)	2.2	1.0	1.0	0.7	0.5
Pr > F	0.0037	<0.0001	0.1351	<0.0001	<0.0001

[1]Grain yield reported on a 13% moisture basis.
[2]Grain protein reported on a 12% moisture basis.
[3]n= 9 location-years.
Bold and underline are highest value in column and bolded lines are statistically similar to highest value based off LSD (α=0.05).

Table 5. Sawfly cutting in 2025 from North Central and Northeastern, MT (5 locations).

ID	Stem type	Sawfly cutting[1] (%)	Solid stem score[2] (5-25)	Plant height (inches)
MTD19011	hollow	27.9	10	32.8
MTD19241	solid	6.1	25	31.1
MT Blackbeard	hollow	25.3	9	34.6
MT Raska	hollow	8.9	9	26.1
Lustre	hollow	22.5	10	32.9
AAC Stronghold	solid	3.0	25	31.2
Alzada	hollow	30.6	12	27.5
CDC Defy	hollow	31.0	9	34.1
Divide	hollow	20.9	10	33.8
Joppa	hollow	**40.3**	9	33.1
ND Riveland	hollow	20.7	9	34.1
ND Stanley	hollow	31.1	10	31.3
Mean		22.4	12	31.9
LSD (0.05)		8.5	/	1.2

[1]Visual estimation of sawfly cutting based on plant lodging.
[2]Stems were cut at five internodes and rated on a scale of 1-5, with 1 being completely hollow and 5 being completely solid. Score is the sum of the five internodes.

Table 6. Durum seed quality evaluation by USDA-ARS Fargo, ND (20 location-years, 2022-2024).

ID	Test weight	Large seeds	Individual seed weight[1]	Individual seed diameter[1]	Grain protein[2]	Grain ash[3]	Falling number
	(lbs/bu)	(%)	(mg)	(mm)	(%)	(%)	(sec)
Alzada	59.7	**64.5**	**41.2**	**2.97**	14.2	**1.53**	**511.6**
Divide	60.7	46.1	38.4	2.79	14.4	1.44	436.6
Joppa	60.8	40.9	38.8	2.76	14.2	**1.49**	438.4
MT Blackbeard	60.8	**65.5**	**41.0**	**2.92**	14.3	**1.51**	478.8
MT Raska	**61.6**	49.8	35.8	2.80	**14.7**	**1.49**	450.3
MTD19011	60.2	53.6	**40.2**	2.84	14.4	1.45	475.4
MTD19241	60.7	39.5	35.1	2.72	14.6	**1.46**	460.5
Mountrail	60.1	35.2	38.0	2.75	14.5	**1.49**	436.8
ND Riveland	60.4	52.1	40.1	2.82	14.5	**1.50**	472.8
WB8148	60.2	40.8	36.3	2.77	14.5	**1.50**	482.3
Mean	60.5	48.8	38.5	2.81	14.4	1.49	464.3
LSD (0.05)	0.5	4.8	1.0	0.08	0.4	0.07	25.1
Pr > F	<0.001	<0.001	<0.001	<0.001	0.129	<0.001	<0.001

[1]Measured by Single Kernel Characterization System.
[2]Grain protein reported on a 12% moisture basis.
[3]Grain ash reported on a 14% moisture basis.
Bold and underline are highest value in column and bolded lines are statistically similar to highest value based off LSD (α=0.05).

Table 7. Durum semolina quality evaluation by USDA-ARS Fargo, ND (20 location-years, 2022-2024).

ID	Semolina yield[1] (%)	Semolina protein[2] (%)	Semolina ash[2] (%)	Brightness[3] (*L*)	Yellowness[3] (*b**)	Mixograph Peak Time (Min)	Gluten index[4] (0-100)
Alzada	**63.8**	**13.1**	**<u>0.73</u>**	83.8	**31.5**	**4.5**	**<u>93.9</u>**
Divide	63.5	13.0	0.66	**84.6**	28.1	3.7	75.7
Joppa	63.3	12.8	0.67	**84.6**	30.8	4.4	84.4
MT Blackbeard	63.5	12.8	0.70	84.4	30.6	**4.7**	**93.8**
MT Raska	**<u>64.2</u>**	**13.2**	0.66	84.2	29.0	4.2	77.6
MTD19011	**63.8**	13.0	0.65	84.2	30.7	3.9	70.2
MTD19241	61.2	**13.2**	0.65	84.1	**<u>31.9</u>**	3.9	64.8
Mountrail	63.5	**<u>13.4</u>**	0.69	**<u>84.7</u>**	26.4	2.4	23.9
ND Riveland	60.4	**13.1**	0.66	84.4	30.5	4.3	**86.6**
WB8148	62.6	**13.4**	0.70	83.8	**31.6**	**<u>4.8</u>**	**92.6**
Mean	63.0	13.1	0.68	84.3	30.1	4.1	76.4
LSD (0.05)	0.6	0.4	0.02	0.2	0.4	0.2	8.1
Pr>F	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001

[1]Milling yield from Brabender Quadramat Jr. milling and separated with a U.S. #35 sieve.
[2]Reported on a 14% moisture basis.
[3]CIELAB color space.
[4]Data from 6 location-years.
Bold and underline are highest value in column and bolded lines are statistically similar to highest value based off LSD (α=0.05).

Table 8. Durum stem rust greenhouse evaluation 2026 (Dr. Li Huang, MSU, Bozeman, MT).

ID	Infection Type[1]	Level of Reaction
Alzada	0	IR
Joppa	;	VR
Mountrail	0	IR
MT Blackbeard	;	VR
MT Raska	;1=	R
MTD19011	;1=	R
ND Riveland	;	R
McNair (sus)	4	S

[1]Inoculated with *Puccinia graminis* isolate TPMKC-61208 on 1/05/2026 scored 1/19/2026. 0 = immune (IR), ";" = Very Resistant (VR), 1=Resistant (R), 2 = Moderately resistant (MR), 3 = Moderately susceptible (MS), 4 = Susceptible (S), Chlorosis (C). Variations are given by + and = to indicate more or less than usual. Observation determined based on 5-10 plants.

Table 9. Durum fungal leaf spot greenhouse evaluation 2022-2024 (Dr. Zhaohui Liu, NDSU, Fargo, ND).

ID	ToxA[1]	Ptr2[2]	Dw5[2]	Sn4[3]
Alzada	0	3.1	3.3	2.7
Divide	3	3.1	2.7	2.4
Joppa	3	2.8	3.0	3.2
Lustre	3	2.2	1.2	3.0
Mountrail	0	3.5	3.2	2.9
MT Blackbeard	3	1.8	3.3	2.6
MT Raska	3	1.8	1.2	2.1
MTD19011	3	2.2	2.4	3.3
MTD19241	3	2.2	1.2	2.8
ND Riveland	0	2.4	2.5	2.9
6B365 (sus check)	0	4.1	2.3	2.9
6B662 (sus check)	0	2.3	3.8	3.7
Glenlea (sus check)	3	3.5	2.8	4.4
Salamouni (res check)	0	1.1	1.0	2.6
Mean	/	2.6	2.4	2.9
LSD (0.05)	/	0.9	0.8	2.2
Pr<F	/	<0.0001	<0.0001	0.5973

[1]*P. tritici-repentis* (Ptr) ToxA: 0=insensitive; 3=sensitive. ToxA sensitivity is conferred by wheat *Tsn1*.
[2]Evaluation with Ptr race 2 (predominant in North Dakota) and Ptr isolate DW5 using a 0-5 scale, 1,2=resistant, 3=moderately susceptible, 4, 5=highly susceptible, averaged over three plants per year.
[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, averaged over three plants.

Table 10. Durum stripe rust field evaluation 2022-2025 (Dr. Xianming Chen, USDA-ARS, Pullman, WA).

ID	Infection type[1,2]	Infection[2] (%)
Alzada	3.8	17.5
Divide	3.0	15.0
Joppa	4.3	30.0
Lustre	4.3	26.3
Mountrail	3.3	25.0
MT Blackbeard	5.0	40.0
MT Raska	6.8	60.0
MTD19011	2.8	15.0
MTD19241	2.8	17.5
ND Riveland	3.5	25.0
AvS (sus check)	9.0	100.0
Mean	4.4	33.8
LSD (0.05)	1.6	15.7
Pr >F	<0.0001	<0.0001

[1]Infected with naturally occurring *Puccinia striiformis*. 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, 0-3 are considered resistant, 4-6 intermediate, and 7-9 susceptible.
[2]Data collected from site near Pullman, WA at growth stage Feekes 10.54 in early July.

Table 11. Durum Fusarium head blight field evaluation 2022-2024 (Dr. Frankie Crutcher, EARC, Sidney, MT).

ID	Incidence[1] (%)	FDK[2] (%)	Severity[3] (%)	Index[4]	DON[5] (ppm)
Alzada	99.3	47.2	67.4	66.9	30.6
Divide	75.9	25.9	31.4	26.1	16.7
Joppa	87.4	45.0	36.3	32.8	19.3
Lustre	84.4	30.9	44.5	39.5	20.3
MT Blackbeard	79.3	36.1	35.7	31.1	24.5
MT Raska	98.1	37.2	54.7	53.9	22.9
MTD19011	87.4	25.0	37.6	33.5	14.7
MTD19241	83.7	27.8	38.9	34.1	18.9
Mountrail	89.6	32.8	47.4	43.8	23.7
ND Riveland	78.9	25.7	31.7	27.9	14.9
Mean	86.4	33.6	42.6	39.0	20.5
LSD (0.05)	9.6	10.1	10.9	12.0	4.3
Pr > F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[1]Incidence- Percent of thirty plants per plot that had visible Fusarium head blight symptoms.
[2]FDK- Percent Fusarium diseased kernels.
[3]Severity- Average percent area of head covered by disease. Thirty heads were evaluated for each plot.
[4]Index- Severity X Incidence / 100.
[5]DON- concentration of deoxynivalenol in seed.