

**PROJECT TITLE:**

2015 MONTANA INTERSTATE DURUM VARIETY TRIALS

**PRINCIPAL INVESTIGATORS:**

Chengci Chen, MSU Eastern Agricultural Research Center, Sidney, MT

Email: [cchen@montana.edu](mailto:cchen@montana.edu)

Phone: (406) 433-2208

Michael Giroux, MSU Bozeman, MT

Email: [mgiroux@montana.edu](mailto:mgiroux@montana.edu)

Phone: (406) 994-7877

Andy Hogg, MSU Bozeman, MT

Email: [ahogg@montana.edu](mailto:ahogg@montana.edu)

Phone: (406) 994-1876

**CONTRIBUTORS:**

- Luther Talbert, MSU Bozeman, MT [usslt@montana.edu](mailto:usslt@montana.edu)
- Gadi Reddy [reddy@montana.edu](mailto:reddy@montana.edu) and John Miller [jhmiller@montana.edu](mailto:jhmiller@montana.edu), MSU-WTARC, Conrad, MT
- Peggy Lamb, MSU-NARC, Havre, MT [plamb@montana.edu](mailto:plamb@montana.edu)
- Dave Wichman, MSU-CARC, Moccasin, MT [dwichman@montana.edu](mailto:dwichman@montana.edu)
- Chengci Chen [cchen@montana.edu](mailto:cchen@montana.edu) and Joyce Eckhoff (retired 5/2015), MSU-EARC, Sidney, MT
- Austin Link, NDSU-WREC, Williston, ND [austin.t.link@ndsu.edu](mailto:austin.t.link@ndsu.edu)
- Linda Dykes, USDA-ARS, Fargo, ND [linda.dykes@ars.usda.gov](mailto:linda.dykes@ars.usda.gov)

**OBJECTIVE:**

To test advanced experimental durum lines for agronomic and quality traits compared to elite varieties.

**METHODS:**

Six advanced experimental durum lines and eight elite durum varieties were tested at five Montana State University Agricultural Experiment Centers and the North Dakota State University Williston Research Extension Center. There were three replicates of each line/variety grown at each location and Mountrail was used as the check variety. Sub-samples from the three replicates per line per location were bulked and submitted to Linda Dykes at the USDA-ARS in Fargo, ND for analysis of seed traits, milling quality, semolina quality, and mixograph performance. Individual research center data and analysis was provided by the contributors. The experiments were grown under rainfed conditions with the exception of the Eastern Agricultural Research Center (EARC) where irrigation was provided. Due to the significant impact on all agronomic traits measured, data from EARC was omitted from the line/variety agronomics statewide summary in Table 2. Agronomic data from EARC can be found in Table

7. The samples provided to the USDA from EARC were included in the statewide line/variety quality summaries. Information on the experimental sites can be found in Table 1, agronomic results are presented in Tables 2-8, line/variety summaries of the USDA quality data is presented in Tables 9-11, and results from individual research centers are presented in tables 12-17.

#### **AGRONOMIC RESULTS SUMMARY:**

For statewide averages from the five rainfed experiment locations there was no significant difference between the lines/varieties tested for yield, however the highest yielding line was MT112219 (30.3 bu/ac) followed by line MT112463 (29.9 bu/ac) (Table 2). The check variety Mountrail had a yield of 29.1 bu/ac. Line MT101694 and Divide had lowest yield (26.5 bu/ac) of all the lines tested under rainfed conditions (Table 2). Under irrigated conditions at EARC line MT101717 (81.9 bu/ac) was the highest yielding line followed by MT112444 (81.1 bu/ac) and MT112219 (77.4 bu/ac) however these lines were not significantly higher than the check Mountrail (73.2 bu/ac) (Table 7). Line MT101694 (54.3 bu/ac) was also the lowest yielding line under irrigated conditions and significantly lower than Mountrail (73.2 bu/ac) (Table 7). Under both rainfed and irrigated conditions MT101717 (59.8 lb/bu and 63.9 lb/bu respectively) had the highest test weight which was significantly higher than Mountrail (57.1 lb/bu and 62.3 lb/bu respectively) (Tables 2 and 7). Line MT112219 also had a significantly higher test weight compared to Mountrail under both rainfed (58.4 vs 57.1 lb/bu) and irrigated conditions (63.3 vs 62.3 lb/bu) (Table 2 and 7). Under rainfed conditions line MT112444 (56.5 lb/bu) had the lowest test weight and under irrigated conditions line MT112434 (59.8 lb/bu) had the lowest test weight followed by MT112444 (60.7 lb/bu) which were both significantly lower than Mountrail (62.3 lb/bu) (Tables 2 and 7). All the experimental lines except MT101694 had significantly lower protein (15.1-15.7%) than Mountrail (16.3%) under rainfed conditions with line MT112463 having the lowest protein (15.1%) (Table 2). Under irrigated conditions at EARC lines MT101694 (12.7%), MT101717 (11.6%), MT112219 (12.5%), and MT112444 (12.3%) had significantly lower protein than Mountrail (13.7%) (Table 7). Under both conditions all six experimental lines had an earlier heading date compared to Mountrail (Tables 2 and 7). Line MT101717 had the shortest plant height of all the lines under both rainfed (22.5 in) and irrigated conditions (29.5 in) (Tables 2 and 7). All experimental lines were significantly shorter than Mountrail except MT101694.

**Table 1. Site information for six testing sites across Montana and North Dakota in 2015.**

Location	Bozeman	WTARC	NARC	CARC	EARC	WREC
Latitude	45° 41'	48° 18'	48° 29'	47° 03'	47° 46'	48° 08'
Longitude	111° 00'	111° 55'	109° 48'	109° 57'	104° 14'	103° 44'
Planting Date	4/29/2015	4/9/2015	4/13/2015	4/10/2015	4/22/2015	4/23/2015
Harvest Date	8/14/2015	8/3/2015	8/3/2015	8/12/2015	8/7/2015	8/11/2015
Crop Year Precipitation	12.52 in	9.02	NA	NA	11.47 in	9.51 in
Season Precipitation	6.58 in	4.74	7.46 in	NA	8.77 in	8.16 in
Irrigated	rainfed	rainfed	rainfed	rainfed	5/27, 6/14 1.25"	rainfed
Herbicide	Huskie  15oz/acre (6/3/15)	RT3 pre-plant spray 32 oz/ac  4/8/15	Brox-M, 24 oz/ac applied 5/27	NA	Full Deck 16 oz/ac and Axial 16 oz/ac, Avaris 7 oz/ac, applied 5/31	Prosaro 7oz/acre (6/30/15) and Wolverine/Tilt @ 1.6 qt/ac and 3oz/ac applied 5/29
Soil Fertility	available N  99lb/acre	Residual soil NO <sub>3</sub> to 4 ft: 15.1 lbs/ac. Residual soil P and K to 6 in: 17 and 375 ppm	Residual soil N to 4 ft: 75 lb N/ac; Residual soil P to 6 in: 17 ppm	50 N in top foot	Residual soil N to 4 ft:73.5 lb N/ac; Residual soil P to 6 in: 20.5 ppm	Soil test to 6" in ppm: 32P : 314K OM- 2.2 pH-6.1 Soil test to 24" in lb/a: 39N
Fertilizer applied	46-0-0	11-22-0 lbs/ac. of N-P-K: w/seed and a 172-0-20 blend of urea and potash broadcast at planting	N-P205- K20 100-20- 10	10-15- 10- 5NPKS with seed +60 N	95 lb/ac 46-0-0	10N : 47P2O5 : 0K2O
Previous crop	lentil	Chemical fallow	field pea	lentil	safflower	soybeans

		barley stubble				
<b>Comments</b>	drought during growing period	very warm and dry June	NA	NA	conditions were dry at planting	NA

**-Information provided by contributors. NA- not available/provided**

**Table 2. Agronomic data averages obtained from durum yield trials at the five rainfed locations in 2015.**

<b>Line</b>	<b>Yield (bu/ac)</b>	<b>Test Weight (lb/bu)</b>	<b>NIR Protein (%) (12% mb)</b>	<b>Heading Date (Julian)</b>	<b>Plant Height (in)</b>
Alkabo	28.4	58.3	16.3	174	27.3
Carpio	27.7	57.2	16.5	<b>176</b>	27.8
Divide	<b>26.5</b>	58.0	16.6	175	28.3
Grenora	28.2	57.7	15.9	175	26.2
Joppa	28.0	58.2	16.4	175	28.3
Mountrail	29.1	57.1	16.3	175	26.5
MT101694	26.5	58.1	16.1	174	<b>28.5</b>
MT101717	27.6	<b>59.8</b>	15.7	173	22.7
MT112219	<b>30.3</b>	58.4	15.7	171	24.6
MT112434	28.6	57.4	15.6	171	<b>22.5</b>
MT112444	27.7	<b>56.5</b>	15.6	171	24.0
MT112463	29.9	57.5	<b>15.1</b>	172	24.3
Silver	28.2	57.0	16.6	<b>170</b>	23.3
Tioga	29.2	58.6	<b>16.8</b>	175	28.2
Mean	28.3	57.8	16.1	173	25.9
CV (%)	33.3	2.6	4.7	3	17.5
P value	NS	<0.0001	<0.0001	<0.0001	<0.0001
LSD (0.05)	NS	0.8	0.5	1.0	2.1

**-bolded data represent the highest and lowest values for each trait.**

**-ANOVA was used to determine significance; NS=not significant.**

**Table 3. Agronomic data obtained from durum yield trial conducted under rainfed conditions at MSU-Bozeman, MT, 2015.**

<b>Line</b>	<b>Yield (bu/ac)</b>	<b>Test Weight (lb/bu)</b>	<b>NIR Protein (%) (12% mb)</b>	<b>Heading Date (Julian)</b>	<b>Plant Height (In)</b>
Alkabo	26.1	59.8	16.2	180	23.1
Carpio	23.3	<b>58.1</b>	16.2	181	22.6
Divide	<b>22.8</b>	59.7	16.6	<b>182</b>	23.6
Grenora	26.5	59.1	15.7	181	22.2
Joppa	24.5	59.6	15.9	181	24.6
Mountrail	23.6	58.3	<b>16.8</b>	181	23.2
MT101694	24.3	59.0	15.7	181	<b>24.8</b>
MT101717	24.8	<b>60.3</b>	15.7	180	<b>19.2</b>
MT112219	25.3	59.3	15.4	178	20.7
MT112434	23.4	59.0	15.8	178	18.8
MT112444	23.1	58.6	15.4	178	22
MT112463	23.7	59.0	<b>15.3</b>	178	19.6
Silver	24.7	59.0	16.4	<b>177</b>	20.5
Tioga	<b>27.6</b>	59.7	16.4	181	24.5
Mean	24.6	59.2	16.0	180	22.1
CV (%)	7.1	0.6	3.0	0.3	5.8
P value	NS	<0.001	0.01	<0.001	<0.001
LSD(0.05)	NS	0.6	0.8	0.8	2.1

**-bolded data represent the highest and lowest values for each trait.**

**-ANOVA was used to determine significance; NS=not significant.**

**Table 4. Agronomic data obtained from a durum yield trial conducted under rainfed conditions at Western Triangle Agricultural Research Center, Conrad, MT 2015.**

<b>Line</b>	<b>Yield (bu/ac)</b>	<b>Test Weight (lb/bu)</b>	<b>NIR Protein (%) (12% mb)</b>	<b>Heading Date (Julian)</b>	<b>Plant Height (in)</b>
Alkabo	39.7	58.8	15.6	173	32.3
Carpio	43.1	57.5	15.8	<b>174</b>	32.7
Divide	<b>35.7</b>	58.3	17.2	171	32.3
Grenora	39.4	58.2	15.9	172	29.3
Joppa	41.9	58.7	16.0	172	<b>34.3</b>
Mountrail	43.7	<b>57.2</b>	15.8	173	33.0
MT101694	41.3	59.8	16.1	172	33.0
MT101717	36.5	<b>61.2</b>	15.7	170	24.7
MT112219	<b>46.4</b>	59.0	15.4	167	24.7
MT112434	40.8	58.3	15.8	<b>166</b>	<b>22.7</b>
MT112444	44.0	57.2	<b>15.0</b>	167	26.7
MT112463	42.3	57.8	15.3	167	26.7
Silver	39.8	58.6	16.4	166	26.3
Tioga	39.4	59.8	<b>17.5</b>	172	33.0
Mean	41	58.6	16	170.1	29.3
CV (%)	12.7	1.5	3.9	0.3	4.8
P-Value	NS	0.0004	0.0032	<0.0000	<0.0000
LSD (0.05)	NS	1.5	1	0.9	2.4

**-bolded data represent the highest and lowest values for each trait.**

**-ANOVA was used to determine significance; NS=not significant.**

**Table 5. Agronomic data obtained from a durum yield trial conducted under no-till rainfed fallow conditions at the Northern Agricultural Research Center Havre, MT, 2015.**

Line	Yield (bu/ac)	Test Weight (lb/bu)	NIR Protein (%) (12% mb)	Heading Date (Julian)	Plant Height (In)	Stand (%)	Moisture (%)	Falling Number (sec)	Sawfly Cutting (%)
Alkabo	35.0	56.7	16.5	167	30.8	88.1	8.7	321	0.7
Carpio	34.6	56.2	17.0	<b>169</b>	32.2	86.4	8.8	359	1.0
Divide	34.9	55.4	17.2	168	31.7	91.4	8.5	342	0.3
Grenora	<b>31.3</b>	55.8	16.2	167	31.3	<b>80.7</b>	8.4	309	0.3
Joppa	34.8	55.8	16.6	167	31.4	91.6	8.7	335	2.0
Mountrail	38.8	55.9	16.5	169	31.0	91.9	8.6	346	<b>0.0</b>
MT101694	32.5	55.6	16.9	167	<b>34.9</b>	<b>97.4</b>	<b>8.2</b>	336	<b>5.0</b>
MT101717	34.4	<b>58.5</b>	16.1	166	26.8	93.5	<b>8.9</b>	358	0.7
MT112219	<b>42.0</b>	57.3	15.8	163	28.8	97.1	8.8	<b>365</b>	0.3
MT112434	38.7	55.8	15.7	164	<b>24.8</b>	94.8	8.6	342	0.3
MT112444	36.9	54.4	15.8	164	26.7	94.8	8.3	365	1.0
MT112463	37.7	55.2	<b>15.5</b>	165	27.7	95.8	8.4	353	0.3
Silver	35.2	<b>54.2</b>	16.7	<b>162</b>	25.5	96.7	8.4	<b>302</b>	1.0
Tioga	34.4	55.7	<b>17.3</b>	168	33.6	92.9	8.4	310	2.3
Mean	35.8	55.9	16.4	166	29.8	92.4	8.6	338	1.1
CV (%)	5.9	1	1.6	0.4	6.3	5.2	1.7	1.8	91.1
P-Value	0.0002	<.0001	<.0001	<.0001	<.0001	0.0116	<.0001	<.0001	0.0002
LSD(0.05)	3.5	0.9	0.5	1	3.1	8	0.2	11	1.7

**-bolded data represent the highest and lowest values for each trait.**

**-ANOVA was used to determine significance.**



**Table 6. Agronomic data obtained from a durum yield trial conducted under rainfed no-till continuous cropping conditions at the Central Agricultural Research Center, Moccasin, MT 2015.**

<b>Line</b>	<b>Yield (bu/ac)</b>	<b>Test Weight (lb/bu)</b>	<b>NIR Protein (%) (12% mb)</b>	<b>Heading Date (Julian)</b>	<b>Plant Height (in)</b>
Alkabo	22.8	58.3	16.9	177	28.3
Carpio	21.5	56.1	17.3	<b>177</b>	28.7
Divide	21.7	58.4	16.8	177	<b>29.9</b>
Grenora	27.3	58.0	16.3	177	28.3
Joppa	21.8	58.0	<b>17.7</b>	177	28.3
Mountrail	22.5	<b>55.9</b>	17.7	177	26.4
MT101694	<b>18.9</b>	58.1	16.9	177	28.7
MT101717	27.4	<b>59.1</b>	16.1	176	25.6
MT112219	27.9	57.7	16.0	174	26.8
MT112434	27.3	56.9	16.1	175	<b>25.2</b>
MT112444	22.4	56.0	16.1	174	25.6
MT112463	<b>28.4</b>	56.7	<b>15.8</b>	175	26.4
Silver	26.8	56.0	17.1	<b>172</b>	26.4
Tioga	25.3	58.9	17.2	177	26.7
Mean	24.4	57.4	16.7	176	27.2
CV (%)	16	0.7	3.9	0.3	2.1
P-value	NS	0.00	<0.05	0.00	NS
LSD(0.05)	NS	0.9	0.7	0.9	NS

**-bolded data represent the highest and lowest values for each trait.**

**-ANOVA was used to determine significance; NS=not significant.**

**Table 7. Agronomic data obtained from durum yield trial conducted under irrigated conditions at Sidney, MT, 2015.**

<b>Line</b>	<b>Yield (bu/ac)</b>	<b>Test Weight (lb/bu)</b>	<b>NIR Protein (%) (12%mb)</b>	<b>Heading Date (Julian)</b>	<b>Plant Height (in)</b>
Alkabo	57.9	62.6	13.1	173	35.0
Carpio	67.8	63.4	12.7	174	<b>36.2</b>
Divide	59.8	62.3	13.8	174	35.0
Grenora	70.2	61.9	13.2	174	33.9
Joppa	66.4	62.7	12.9	174	35.8
Mountrail	73.2	62.3	13.7	<b>175</b>	35.8
MT101694	<b>54.3</b>	60.9	12.7	173	35.4
MT101717	<b>81.9</b>	<b>63.9</b>	<b>11.6</b>	172	<b>29.5</b>
MT112219	77.4	63.3	12.5	172	29.9
MT112434	61.3	<b>59.8</b>	13.2	172	27.6
MT112444	81.1	60.7	12.3	172	31.1
MT112463	67.9	61.6	13.1	172	30.8
Silver	69.5	60.7	<b>13.6</b>	<b>172</b>	29.9
Tioga	63.0	62.3	12.9	174	35.8
Mean	69.5	62.0	12.9	173	32.7
CV (%)	11.4	0.8	4.4	0.6	3.0
P-value	0.004	<0.0001	0.0123	<0.0001	<0.0001
LSD(0.05)	13.2	0.8	1.0	0.6	2.0

**-bolded data represent the highest and lowest values for each trait.**

**-ANOVA was used to determine significance.**

**Table 8. Agronomic data obtained from a durum yield trial conducted under rainfed conditions at Williston Research and Education Center, Williston, ND, 2015.**

<b>Line</b>	<b>Yield (bu/ac)</b>	<b>Test Weight (lb/bu)</b>	<b>NIR Protein (%) (12% mb)</b>	<b>Heading Date (Julian)</b>	<b>Plant Height (in)</b>	<b>Stress (%)</b>	<b>Stand (%)</b>
Alkabo	18.4	58.0	16.1	175	22	15	98
Carpio	16.2	58.0	16.0	<b>178</b>	23	15	<b>99</b>
Divide	17.3	58.2	15.0	175	<b>24</b>	12	99
Grenora	16.4	57.4	15.3	176	20	15	99
Joppa	16.9	58.7	15.7	177	23	17	98
Mountrail	16.9	58.0	14.7	177	19	13	99
MT101694	15.6	57.9	15.1	175	21	20	98
MT101717	15.1	<b>59.7</b>	15.0	174	<b>17</b>	22	98
MT112219	<b>10.1</b>	58.7	15.7	173	22	<b>48</b>	98
MT112434	12.7	57.2	14.8	174	21	32	99
MT112444	12.2	<b>56.5</b>	15.6	173	19	22	96
MT112463	17.5	58.6	<b>13.8</b>	173	21	15	98
Silver	14.7	57.4	<b>16.2</b>	<b>173</b>	18	22	<b>96</b>
Tioga	<b>19.4</b>	58.7	15.6	176	23	<b>7</b>	98
Mean	15.7	58.1	15.3	175	21	20	98
CV (%)	13.3	0.8	5.7	1.8	9.5	44.7	2.3
P-value	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	NS
LSD(0.05)	3.5	0.8	NS	1.9	3.3	14.7	NS

**-bolded data represent the highest and lowest values for each trait.**

**-ANOVA was used to determine significance; NS=not significant.**

## **USDA QUALITY RESULTS SUMMARY:**

Compared to the check variety Mountrail, two experimental lines (MT112219 and MT101717) had an increased test weight which and they also had the largest average test weights of all lines tested. Other MT experimental lines had an average test weight comparable to Mountrail. All MT experimental lines had a lower grain protein content (14.7-15.3%) and individual kernel weight (32.5-35.7 mg) compared to Mountrail (15.7%; 36.5 mg), while Tioga had the highest grain protein content (16%) and Alkabo had the largest seeds (39 mg). Five out of the six MT experimental lines had an increased falling number (426.2-448.3 sec) compared to Mountrail (415.3 sec) while line MT101694 had a significantly lower falling number score (377.2 sec) (Table 9). All experimental MT lines had a slightly lower milling yield (57.9-60.2%) than the check variety Mountrail (60.7%), with the semolina being less bright (83.4-84.2) and five out six being more yellow (26.7-28.6) than Mountrail (84.5 and 25.1 respectively) though not significantly. Mountrail produced the brightest semolina out of all the lines tested. All the MT experimental lines also had lower semolina protein (13.4-14.5%) compared to Mountrail (15.1%) (Table 10). The six MT experimental lines had a superior mixograph pattern (4-7.2) compared to the Mountrail check (3.0) which led to longer mixing times and larger midline peak widths. Even though Mountrail has high grain and semolina protein content it is of poor functionality (Table 11).

**Table 9. Seed quality from multi-location durum yield trials conducted in 2015.**

Line	Test Weight (lb/bu)	Large %	Small %	Hardness Index	SKW (mg)	Diameter (mm)	NIR Protein (12%mb)	Whole Meal Oven Ash (14% mb)	Falling Number (sec)
Alkabo	59.7	42.8	18.2	83.8	<b>39.0</b>	<b>2.7</b>	15.6	1.5	416.2
Carpio	59.1	42.3	18.5	84.5	36.8	2.6	15.7	1.5	419.8
Divide	59.5	35.0	21.2	85.0	36.6	2.6	15.9	<b>1.5</b>	420.7
Grenora	59.0	36.7	19.3	86.6	38.0	2.7	15.4	1.5	409.8
Joppa	59.5	35.3	24.2	85.4	36.8	2.6	15.6	1.5	414.3
Mountrail	58.6	27.8	25.8	83.9	36.5	2.6	15.7	1.5	415.3
MT101694	58.9	37.8	21.0	87.0	35.7	2.6	15.3	1.5	<b>377.2</b>
MT101717	<b>60.8</b>	<b>22.5</b>	<b>35.2</b>	<b>92.0</b>	<b>32.5</b>	<b>2.5</b>	14.8	1.5	<b>448.3</b>
MT112219	59.8	32.3	26.7	84.3	35.5	2.6	15.0	1.5	426.2
MT112434	<b>58.2</b>	35.3	22.5	<b>79.2</b>	35.2	2.6	15.2	<b>1.6</b>	<b>448.3</b>
MT112444	57.5	36.0	21.8	82.0	33.9	2.6	14.8	1.5	438.0
MT112463	58.9	<b>43.0</b>	19.8	83.4	34.1	2.6	<b>14.7</b>	1.6	427.7
Silver	58.1	30.7	24.3	84.0	33.9	2.6	15.6	1.6	399.0
Tioga	59.5	40.2	<b>18.7</b>	83.0	38.3	2.7	<b>16.0</b>	1.5	408.8
Mean	59.1	35.6	22.7	84.6	35.9	2.6	15.4	1.5	419.3
CV%	1.2	15.0	16.9	2.5	3.3	1.6	3.0	3.3	5.6
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
LSD(0.05)	0.8	6.2	4.4	2.5	1.4	0.0	0.5	0.1	27.1

**-bolded data represent the highest and lowest values for each trait.**

**-ANOVA was used to determine significance.**

**-SKW=single kernel weight**

**Table 10. Milling and semolina quality data from multi-location durum yield trials conducted in 2015.**

Line	Bran (g)	Shorts (g)	Total Semolina (g)	Milling Yield %	Leco Protein (12% mb)	Oven Ash (14% mb)	Brightness L*	Yellowness b*
Alkabo	65.3	18.5	127.4	60.3	14.6	0.6	84.4	28.5
Carpio	<b>63.6</b>	19.6	128.0	60.6	14.7	0.7	84.0	<b>29.9</b>
Divide	65.2	17.9	128.4	60.7	14.6	0.6	84.6	26.8
Grenora	66.1	18.6	126.5	59.9	14.3	0.6	84.6	27.9
Joppa	63.6	18.7	<b>129.1</b>	<b>61.1</b>	14.8	<b>0.6</b>	84.3	28.7
Mountrail	64.9	18.2	128.3	60.7	<b>15.1</b>	0.7	<b>84.5</b>	25.1
MT101694	67.1	19.6	124.9	59.1	14.5	0.7	84.2	<b>24.5</b>
MT101717	<b>69.4</b>	19.5	<b>122.4</b>	<b>57.9</b>	13.9	0.6	83.8	28.6
MT112219	64.4	<b>19.9</b>	127.3	60.2	13.8	0.7	83.6	26.7
MT112434	67.7	19.3	124.1	58.8	14.0	<b>0.7</b>	83.8	28.7
MT112444	68.0	19.7	123.9	58.6	13.7	0.7	<b>83.4</b>	28.2
MT112463	66.8	18.7	126.1	59.6	<b>13.4</b>	0.7	83.9	28.5
Silver	68.5	18.4	124.8	59.0	14.5	0.6	84.0	24.8
Tioga	64.9	<b>17.7</b>	129.0	60.9	<b>15.1</b>	0.7	84.4	28.2
Mean	66.1	18.9	126.4	59.8	14.4	0.7	84.1	27.5
CV%	2.1	4.4	1.5	1.4	3.5	5.2	0.3	2.4
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
LSD(0.05)	1.6	1.0	2.1	1.0	0.6	0.03	0.3	0.8

**-bolded data represent the highest and lowest values for each trait.**

**-ANOVA was used to determine significance.**

Table 11. Mixograph data from multi-location durum yield trials conducted in 2015.

Line	Mixograph pattern	Midline Peak Time (min)	Midline Peak Value %	Midline Peak Width %	Midline Peak Integral %TQ*min	Bandwidth at 8 min %	Midline Right Slope (%/min)
Alkabo	5.8	3.2	61.9	<b>22.9</b>	147.9	11.0	-2.4
Carpio	<b>7.5</b>	4.5	63.9	29.2	217.2	<b>21.4</b>	-1.7
Divide	6.3	3.7	60.2	24.8	165.4	12.0	-1.9
Grenora	5.7	3.2	61.2	25.1	141.4	9.6	-2.1
Joppa	7.0	4.0	61.8	<b>29.3</b>	178.5	16.7	-1.6
Mountrail	<b>3.0</b>	<b>2.6</b>	<b>64.5</b>	21.8	118.8	<b>3.8</b>	<b>-5.0</b>
MT101694	4.0	3.2	60.2	23.0	<b>137.5</b>	7.0	-3.3
MT101717	5.5	3.8	55.2	21.0	157.5	11.5	<b>-0.5</b>
MT112219	6.8	4.7	56.0	25.0	194.9	20.0	-1.1
MT112434	7.2	5.0	<b>54.6</b>	27.5	211.3	21.1	-0.8
MT112444	7.0	<b>5.1</b>	56.0	24.8	<b>219.7</b>	19.2	-0.8
MT112463	7.2	3.8	59.5	28.9	167.2	18.6	<b>-0.5</b>
Silver	6.8	4.5	56.9	25.8	192.9	16.9	-1.2
Tioga	6.7	4.0	61.2	25.8	178.6	14.4	-2.4
Mean	6.2	3.9	59.5	25.4	173.5	14.5	-1.8
P value	<0.0001	<0.0001	<0.0001	0.0	<0.0001	<0.0001	0.0
LSD(0.05)	0.9	0.6	3.7	4.7	27.2	3.6	1.9
CV%	13.1	12.3	5.5	16.2	13.6	21.3	-89.0

-bolded data represent the highest and lowest values for each trait.

-ANOVA was used to determine significance.

**Table 12. Bozeman, WTARC, and NARC seed quality data.**

Location	Line	Test			Hardness Index	SKW (mg)	Diameter (mm)	NIR Protein (12%mb)	Whole	Falling Number (sec)
		Weight (lb/bu)	Large %	Small %					Meal Oven Ash (14% mb)	
Bozeman, MT	Alkabo	61.4	<b>58.0</b>	<b>6.0</b>	84.2	42.0	2.8	16.2	1.54	391.0
Bozeman, MT	Carpio	59.7	57.0	9.0	82.5	39.4	2.7	16.2	1.58	391.0
Bozeman, MT	Divide	61.1	46.0	12.0	86.3	39.6	2.7	16.6	<b>1.49</b>	400.0
Bozeman, MT	Grenora	60.5	42.0	12.0	87.1	39.6	2.7	15.7	1.56	440.0
Bozeman, MT	Joppa	61.1	46.0	12.0	84.0	40.1	2.7	15.9	1.57	405.0
Bozeman, MT	Mountrail	59.7	26.0	16.0	82.8	38.6	2.7	<b>16.8</b>	1.50	394.0
Bozeman, MT	MT101694	<b>59.5</b>	45.0	15.0	87.7	36.6	2.6	15.7	1.55	<b>355.0</b>
Bozeman, MT	MT101717	61.0	<b>23.0</b>	<b>27.0</b>	<b>90.2</b>	<b>34.1</b>	<b>2.6</b>	15.7	1.54	443.0
Bozeman, MT	MT112219	60.2	35.0	17.0	84.3	36.3	2.7	15.4	1.66	435.0
Bozeman, MT	MT112434	60.0	44.0	14.0	<b>75.9</b>	37.8	2.7	15.8	<b>1.72</b>	<b>450.0</b>
Bozeman, MT	MT112444	59.9	46.0	12.0	81.7	37.1	2.8	15.4	1.58	<b>450.0</b>
Bozeman, MT	MT112463	60.6	49.0	12.0	80.6	34.5	2.7	<b>15.3</b>	1.69	<b>450.0</b>
Bozeman, MT	Silver	61.0	49.0	10.0	83.6	37.9	2.8	16.4	1.58	407.0
Bozeman, MT	Tioga	<b>61.6</b>	57.0	8.0	80.2	<b>43.6</b>	<b>2.8</b>	16.4	1.58	365.0
Conrad, MT	Alkabo	58.9	<b>32.0</b>	22.0	86.3	<b>36.5</b>	<b>2.5</b>	15.5	1.35	372.0
Conrad, MT	Carpio	59.0	30.0	<b>21.0</b>	89.8	34.4	2.5	15.6	1.30	390.0
Conrad, MT	Divide	58.6	18.0	28.0	87.1	33.8	2.5	16.5	1.39	388.0
Conrad, MT	Grenora	58.6	22.0	24.0	91.5	34.6	2.5	15.9	1.28	347.0
Conrad, MT	Joppa	59.6	27.0	25.0	91.5	34.9	2.5	15.8	1.30	358.0
Conrad, MT	Mountrail	58.6	17.0	25.0	88.4	34.8	2.5	15.4	1.31	378.0
Conrad, MT	MT101694	59.0	31.0	<b>21.0</b>	90.7	33.7	2.5	15.7	1.33	<b>328.0</b>
Conrad, MT	MT101717	<b>60.2</b>	<b>9.0</b>	<b>39.0</b>	<b>91.7</b>	<b>30.3</b>	<b>2.4</b>	15.6	<b>1.27</b>	<b>447.0</b>
Conrad, MT	MT112219	59.2	21.0	29.0	90.7	32.0	2.4	<b>15.1</b>	1.37	384.0
Conrad, MT	MT112434	57.4	12.0	33.0	85.4	30.8	2.4	15.9	<b>1.50</b>	440.0
Conrad, MT	MT112444	<b>56.5</b>	22.0	27.0	<b>84.3</b>	30.6	2.5	15.1	1.40	405.0
Conrad, MT	MT112463	57.8	<b>32.0</b>	24.0	88.5	32.7	2.5	15.4	1.41	389.0
Conrad, MT	Silver	58.2	16.0	26.0	90.1	33.8	2.5	16.0	1.41	357.0
Conrad, MT	Tioga	58.4	21.0	22.0	88.7	34.3	2.5	<b>16.8</b>	1.40	436.0
Havre, MT	Alkabo	57.3	21.0	26.0	81.8	35.8	2.5	16.5	1.39	439.0
Havre, MT	Carpio	56.5	18.0	25.0	81.8	32.7	2.5	17.4	1.46	<b>450.0</b>
Havre, MT	Divide	56.3	12.0	32.0	82.3	32.6	2.5	17.2	1.47	<b>450.0</b>
Havre, MT	Grenora	56.5	16.0	26.0	81.9	<b>36.5</b>	<b>2.6</b>	15.9	1.41	409.0
Havre, MT	Joppa	56.2	12.0	33.0	80.0	34.3	2.5	16.4	1.40	431.0
Havre, MT	Mountrail	56.2	<b>8.0</b>	37.0	79.0	34.2	2.5	17.0	1.42	<b>450.0</b>
Havre, MT	MT101694	55.9	27.0	<b>23.0</b>	84.9	33.4	2.5	17.1	<b>1.37</b>	434.0
Havre, MT	MT101717	<b>59.0</b>	9.0	<b>40.0</b>	<b>90.6</b>	30.6	<b>2.4</b>	15.8	1.41	<b>450.0</b>
Havre, MT	MT112219	57.9	15.0	33.0	79.4	33.5	2.5	15.9	1.42	<b>450.0</b>
Havre, MT	MT112434	56.0	24.0	24.0	<b>74.9</b>	33.7	2.5	15.8	<b>1.56</b>	<b>450.0</b>
Havre, MT	MT112444	55.0	22.0	26.0	81.2	31.3	2.5	15.9	1.51	<b>450.0</b>
Havre, MT	MT112463	56.0	<b>30.0</b>	25.0	78.1	32.0	2.5	<b>15.1</b>	1.53	<b>450.0</b>
Havre, MT	Silver	<b>55.0</b>	12.0	30.0	79.3	<b>30.1</b>	2.5	16.7	1.53	<b>357.0</b>
Havre, MT	Tioga	56.1	18.0	26.0	80.0	34.1	2.5	<b>18.1</b>	1.46	391.0

**-bolded data represent the highest and lowest values for each trait.**

**-SKW=single kernel weight**



**Table 13. CARC, EARC, and WREC seed quality data.**

Location	Line	Test Weight			Hardness		Diameter (mm)	NIR Protein (12%mb)	Whole	Falling Number (sec)
		(lb/bu)	Large %	Small %	Index	SKW (mg)			Oven Ash (14% mb)	
Moccasin, MT	Alkabo	57.9	<b>9.0</b>	<b>36.0</b>	90.0	<b>32.9</b>	2.4	17.1	1.62	395.0
Moccasin, MT	Carpio	55.8	4.0	39.0	88.4	30.0	2.3	17.3	1.75	388.0
Moccasin, MT	Divide	58.4	5.0	37.0	94.9	30.3	2.4	17.3	1.70	386.0
Moccasin, MT	Grenora	57.1	4.0	39.0	92.8	30.6	2.4	16.8	<b>1.58</b>	363.0
Moccasin, MT	Joppa	57.2	1.0	56.0	89.3	29.2	2.3	17.5	<b>1.80</b>	392.0
Moccasin, MT	Mountrail	55.1	<b>0.0</b>	56.0	<b>84.7</b>	30.2	2.3	<b>18.0</b>	1.67	370.0
Moccasin, MT	MT101694	57.6	4.0	44.0	90.7	30.2	2.4	16.8	1.79	<b>351.0</b>
Moccasin, MT	MT101717	<b>58.6</b>	1.0	<b>72.0</b>	<b>99.0</b>	<b>25.0</b>	<b>2.2</b>	16.0	1.78	<b>450.0</b>
Moccasin, MT	MT112219	57.4	1.0	56.0	88.6	28.7	2.3	16.3	1.70	388.0
Moccasin, MT	MT112434	56.8	3.0	44.0	87.1	29.7	2.4	16.5	1.74	<b>450.0</b>
Moccasin, MT	MT112444	55.3	3.0	45.0	89.9	27.0	2.3	<b>15.8</b>	1.63	423.0
Moccasin, MT	MT112463	56.2	5.0	41.0	87.9	26.0	2.3	16.2	1.71	377.0
Moccasin, MT	Silver	<b>54.9</b>	1.0	54.0	89.0	27.5	2.3	17.0	1.77	383.0
Moccasin, MT	Tioga	58.3	5.0	40.0	90.1	32.8	<b>2.4</b>	17.3	1.77	440.0
Sidney, MT	Alkabo	61.5	76.0	8.0	83.0	43.4	2.9	14.0	1.75	<b>450.0</b>
Sidney, MT	Carpio	62.2	<b>79.0</b>	7.0	84.2	43.5	2.9	13.1	1.72	<b>450.0</b>
Sidney, MT	Divide	61.3	76.0	7.0	82.9	44.1	2.9	13.9	1.73	<b>450.0</b>
Sidney, MT	Grenora	60.9	<b>79.0</b>	<b>5.0</b>	86.8	<b>44.2</b>	3.0	13.9	1.79	<b>450.0</b>
Sidney, MT	Joppa	61.7	71.0	7.0	87.7	41.6	2.8	14.1	1.72	<b>450.0</b>
Sidney, MT	Mountrail	61.3	71.0	9.0	85.8	41.8	2.9	<b>14.2</b>	<b>1.67</b>	<b>450.0</b>
Sidney, MT	MT101694	60.1	63.0	10.0	85.2	40.6	2.8	13.5	1.79	<b>407.0</b>
Sidney, MT	MT101717	<b>63.0</b>	<b>46.0</b>	<b>16.0</b>	<b>92.1</b>	<b>37.0</b>	<b>2.7</b>	<b>12.3</b>	1.76	<b>450.0</b>
Sidney, MT	MT112219	62.5	65.0	12.0	83.9	42.0	2.9	13.1	1.69	<b>450.0</b>
Sidney, MT	MT112434	<b>58.7</b>	69.0	10.0	<b>75.0</b>	39.9	2.8	13.6	<b>1.87</b>	<b>450.0</b>
Sidney, MT	MT112444	59.0	71.0	8.0	78.3	40.6	2.9	12.8	1.77	<b>450.0</b>
Sidney, MT	MT112463	60.5	75.0	7.0	83.4	40.0	2.9	13.5	1.84	<b>450.0</b>
Sidney, MT	Silver	59.1	57.0	12.0	80.1	37.5	2.8	13.2	1.83	<b>450.0</b>
Sidney, MT	Tioga	61.3	78.0	7.0	83.6	42.7	<b>3.0</b>	13.2	1.75	<b>450.0</b>
Williston, ND	Alkabo	61.3	61.0	11.0	77.8	<b>43.2</b>	2.8	<b>14.6</b>	1.27	<b>450.0</b>
Williston, ND	Carpio	61.3	66.0	10.0	80.3	41.1	2.8	14.4	1.27	<b>450.0</b>
Williston, ND	Divide	61.0	53.0	11.0	76.5	39.2	2.7	13.8	1.24	<b>450.0</b>
Williston, ND	Grenora	60.3	57.0	10.0	79.6	42.7	2.8	14.0	1.34	<b>450.0</b>
Williston, ND	Joppa	61.4	55.0	12.0	80.1	41.0	2.8	13.7	<b>1.21</b>	<b>450.0</b>
Williston, ND	Mountrail	60.9	<b>45.0</b>	12.0	82.9	39.5	2.8	12.9	1.33	<b>450.0</b>
Williston, ND	MT101694	61.2	57.0	13.0	82.8	39.5	2.8	13.0	1.38	388.0
Williston, ND	MT101717	<b>62.9</b>	47.0	<b>17.0</b>	<b>88.5</b>	38.3	2.7	13.5	1.28	<b>450.0</b>
Williston, ND	MT112219	61.8	57.0	13.0	78.8	40.8	2.9	13.9	1.37	<b>450.0</b>
Williston, ND	MT112434	60.1	60.0	10.0	76.9	39.4	2.8	13.4	<b>1.46</b>	<b>450.0</b>
Williston, ND	MT112444	<b>59.4</b>	52.0	13.0	76.3	36.9	<b>2.7</b>	13.8	1.32	<b>450.0</b>
Williston, ND	MT112463	62.0	<b>67.0</b>	10.0	81.7	39.4	<b>2.9</b>	<b>12.5</b>	1.42	<b>450.0</b>
Williston, ND	Silver	60.6	49.0	14.0	81.5	<b>36.7</b>	2.7	14.5	1.41	440.0
Williston, ND	Tioga	61.4	62.0	<b>9.0</b>	<b>75.5</b>	42.3	2.9	14.0	1.24	<b>371.0</b>

**-bolded data represent the highest and lowest values for each trait.**

**-SKW=single kernel weight**

**Table 14. Bozeman, WTARC, and NARC milling and semolina quality data.**

Location	Line	Bran (g)	Shorts (g)	Total Semolina (g)	Milling Yield %	Leco			
						Protein (12% mb)	Oven Ash (14% mb)	Brightness L*	Yellowness b*
Bozeman, MT	Alkabo	60.1	19.8	131.4	62.2	14.8	0.6	84.4	27.8
Bozeman, MT	Carpio	<b>58.6</b>	19.9	133.0	62.9	15.5	0.7	<b>83.2</b>	28.7
Bozeman, MT	Divide	59.4	<b>17.7</b>	133.6	<b>63.4</b>	15.0	0.6	84.4	26.9
Bozeman, MT	Grenora	61.2	19.0	131.4	62.1	14.5	0.6	<b>84.5</b>	27.4
Bozeman, MT	Joppa	58.9	20.0	132.1	62.6	15.3	0.6	84.4	27.9
Bozeman, MT	Mountrail	59.7	18.8	131.7	62.7	<b>16.4</b>	0.7	84.4	24.5
Bozeman, MT	MT101694	62.0	20.9	126.5	60.4	15.1	0.7	83.8	24.7
Bozeman, MT	MT101717	<b>65.1</b>	21.3	<b>125.5</b>	<b>59.2</b>	14.4	0.7	83.5	<b>28.7</b>
Bozeman, MT	MT112219	59.6	20.2	131.5	62.2	14.1	0.8	83.6	26.4
Bozeman, MT	MT112434	62.3	19.9	128.3	61.0	14.5	<b>0.8</b>	83.8	28.3
Bozeman, MT	MT112444	62.2	<b>21.4</b>	127.4	60.4	14.2	0.7	83.4	27.5
Bozeman, MT	MT112463	61.1	19.7	129.8	61.6	<b>13.6</b>	0.7	83.4	27.8
Bozeman, MT	Silver	61.3	19.6	130.2	61.7	14.7	<b>0.6</b>	84.3	<b>24.2</b>
Bozeman, MT	Tioga	59.1	18.4	<b>134.2</b>	63.4	15.2	0.7	84.2	28.0
Conrad, MT	Alkabo	69.5	18.6	122.6	58.2	14.7	0.6	84.1	30.0
Conrad, MT	Carpio	<b>66.8</b>	19.1	124.7	59.2	14.6	0.6	84.2	<b>32.4</b>
Conrad, MT	Divide	70.2	18.6	122.5	58.0	15.6	0.6	84.1	28.4
Conrad, MT	Grenora	69.0	19.0	122.7	58.2	14.7	0.6	84.2	29.5
Conrad, MT	Joppa	67.7	18.3	125.2	59.3	14.6	0.6	84.4	30.6
Conrad, MT	Mountrail	67.5	17.9	<b>125.8</b>	<b>59.6</b>	14.8	0.6	<b>84.5</b>	26.8
Conrad, MT	MT101694	69.6	19.9	121.6	57.6	15.0	0.6	83.9	<b>25.8</b>
Conrad, MT	MT101717	73.1	19.0	118.1	56.2	14.7	<b>0.5</b>	83.9	30.5
Conrad, MT	MT112219	68.7	<b>20.5</b>	122.3	57.8	13.9	0.6	<b>83.1</b>	29.3
Conrad, MT	MT112434	73.1	19.5	117.6	55.9	14.6	0.7	83.5	31.2
Conrad, MT	MT112444	<b>73.6</b>	20.3	<b>116.5</b>	<b>55.4</b>	<b>13.6</b>	0.7	83.2	30.5
Conrad, MT	MT112463	71.8	19.3	119.1	56.7	13.7	<b>0.7</b>	83.6	30.9
Conrad, MT	Silver	72.2	19.8	118.9	56.4	14.7	0.6	83.5	25.9
Conrad, MT	Tioga	69.2	<b>17.8</b>	123.6	58.7	<b>16.1</b>	0.6	84.4	31.0
Havre, MT	Alkabo	71.1	18.1	122.0	57.8	15.4	0.6	84.5	27.9
Havre, MT	Carpio	<b>68.1</b>	17.5	<b>124.9</b>	<b>59.3</b>	16.2	0.7	84.4	<b>28.6</b>
Havre, MT	Divide	70.8	<b>17.2</b>	124.0	58.5	16.0	0.7	84.9	24.7
Havre, MT	Grenora	72.6	18.2	121.3	57.2	15.0	0.7	<b>85.0</b>	27.3
Havre, MT	Joppa	69.6	18.1	123.9	58.6	15.8	0.6	84.7	27.7
Havre, MT	Mountrail	69.8	18.0	123.3	58.4	16.3	<b>0.7</b>	84.9	24.7
Havre, MT	MT101694	70.4	18.5	124.3	58.3	16.3	0.6	84.5	<b>22.5</b>
Havre, MT	MT101717	72.3	17.9	122.4	57.6	15.1	<b>0.6</b>	84.0	27.6
Havre, MT	MT112219	70.5	18.5	123.6	58.1	14.6	0.7	84.3	24.0
Havre, MT	MT112434	73.4	18.7	<b>119.6</b>	<b>56.5</b>	14.3	0.6	84.2	27.5
Havre, MT	MT112444	73.5	<b>18.8</b>	120.4	56.6	14.6	0.6	<b>83.7</b>	27.4
Havre, MT	MT112463	72.0	18.1	122.5	57.6	<b>14.2</b>	0.7	84.4	27.3
Havre, MT	Silver	<b>73.6</b>	18.3	121.4	56.9	15.6	0.6	84.3	23.9
Havre, MT	Tioga	<b>70.7</b>	17.7	123.8	58.3	16.9	0.6	84.6	27.7

**-bolded data represent the highest and lowest values for each trait.**

**Table 15. CARC, EARC, and WREC milling and semolina quality data.**

Location	Line	Bran (g)	Shorts (g)	Total Semolina (g)	Milling Yield %	Leco			
						Protein (12% mb)	Oven Ash (14% mb)	Brightness L*	Yellowness b*
Moccasin, MT	Alkabo	73.6	<b>18.6</b>	119.5	56.4	16.2	0.7	83.9	29.8
Moccasin, MT	Carpio	71.7	22.0	119.5	56.1	16.5	0.8	83.4	<b>31.4</b>
Moccasin, MT	Divide	71.5	19.2	<b>122.3</b>	57.4	16.3	0.7	<b>84.1</b>	28.9
Moccasin, MT	Grenora	73.5	20.1	119.2	56.0	15.8	<b>0.7</b>	83.9	29.0
Moccasin, MT	Joppa	<b>70.6</b>	18.7	122.0	<b>57.7</b>	16.8	<b>0.8</b>	83.3	29.5
Moccasin, MT	Mountrail	76.2	20.2	116.1	54.6	<b>17.7</b>	0.8	83.5	26.9
Moccasin, MT	MT101694	76.6	20.3	116.0	54.5	16.2	0.8	83.2	26.6
Moccasin, MT	MT101717	79.1	20.2	112.7	53.2	15.4	0.8	82.8	30.9
Moccasin, MT	MT112219	74.6	21.7	116.4	54.7	15.2	0.8	82.6	28.6
Moccasin, MT	MT112434	75.6	<b>22.6</b>	114.6	53.9	15.4	0.8	82.7	30.5
Moccasin, MT	MT112444	75.9	21.4	116.1	54.4	15.3	0.8	<b>82.2</b>	30.2
Moccasin, MT	MT112463	76.4	19.9	117.4	54.9	<b>14.9</b>	0.7	83.0	30.7
Moccasin, MT	Silver	<b>80.9</b>	21.3	<b>110.3</b>	<b>51.9</b>	16.0	0.8	83.0	<b>25.4</b>
Moccasin, MT	Tioga	74.8	18.7	118.9	56.0	16.8	0.8	83.6	26.8
Sidney, MT	Alkabo	56.1	17.5	136.1	64.9	12.9	0.7	84.6	27.2
Sidney, MT	Carpio	56.3	19.4	134.8	64.0	12.3	0.7	84.3	<b>28.9</b>
Sidney, MT	Divide	57.0	17.7	135.3	64.4	12.6	0.6	84.8	26.0
Sidney, MT	Grenora	57.8	17.9	134.0	63.9	13.1	0.7	84.5	27.1
Sidney, MT	Joppa	57.0	19.1	135.1	64.0	<b>13.3</b>	<b>0.6</b>	84.6	27.9
Sidney, MT	Mountrail	55.8	17.0	<b>138.3</b>	<b>65.5</b>	13.2	0.7	84.6	23.7
Sidney, MT	MT101694	61.8	<b>19.8</b>	129.1	61.3	12.4	0.7	84.6	<b>23.2</b>
Sidney, MT	MT101717	<b>63.2</b>	19.2	<b>127.5</b>	<b>60.7</b>	<b>11.6</b>	0.7	84.3	27.0
Sidney, MT	MT112219	<b>53.5</b>	19.1	137.1	65.4	12.2	0.7	84.1	26.5
Sidney, MT	MT112434	59.4	17.5	132.8	63.3	12.8	0.7	84.1	27.2
Sidney, MT	MT112444	58.5	17.7	133.9	63.7	12.0	0.7	<b>83.8</b>	27.5
Sidney, MT	MT112463	57.8	17.9	135.4	64.1	12.7	<b>0.7</b>	84.3	26.9
Sidney, MT	Silver	61.5	<b>14.8</b>	134.5	63.8	12.3	0.6	84.6	25.0
Sidney, MT	Tioga	57.6	17.9	135.7	64.3	12.5	0.7	<b>84.8</b>	26.7
Williston, ND	Alkabo	61.2	18.2	132.6	62.5	<b>13.5</b>	0.5	84.7	28.3
Williston, ND	Carpio	60.2	<b>19.9</b>	131.2	62.1	13.3	0.6	84.7	<b>29.3</b>
Williston, ND	Divide	62.2	17.1	132.8	62.6	12.0	0.5	85.1	25.9
Williston, ND	Grenora	62.6	17.5	130.4	61.9	12.6	0.6	<b>85.4</b>	26.9
Williston, ND	Joppa	<b>57.8</b>	17.7	136.4	64.4	13.0	0.5	84.6	28.6
Williston, ND	Mountrail	60.1	17.3	134.4	63.5	12.3	0.5	85.2	<b>23.8</b>
Williston, ND	MT101694	61.9	18.0	131.8	62.3	11.9	0.6	85.1	23.9
Williston, ND	MT101717	63.5	19.4	<b>128.2</b>	<b>60.7</b>	12.6	<b>0.5</b>	84.7	26.8
Williston, ND	MT112219	59.2	19.3	132.9	62.9	12.9	0.7	<b>84.0</b>	25.3
Williston, ND	MT112434	62.1	17.7	131.7	62.3	12.3	<b>0.7</b>	84.4	27.8
Williston, ND	MT112444	<b>64.3</b>	18.3	129.3	61.0	12.7	0.6	84.4	26.0
Williston, ND	MT112463	61.8	17.4	132.6	62.6	<b>11.4</b>	0.6	84.9	27.2
Williston, ND	Silver	61.6	16.4	133.3	63.1	13.4	0.5	84.5	24.5
Williston, ND	Tioga	58.2	<b>15.9</b>	<b>137.6</b>	<b>65.0</b>	12.9	0.5	85.1	28.0

**-bolded data represent the highest and lowest values for each trait.**

**Table 16. Bozeman, WTARC, and NARC mixograph data.**

Location	Line	Mixograph pattern	Midline Peak Time (min)	Midline Peak Value %	Midline Peak Width %	Midline Peak Integral %TQ*min	Bandwidth at 8 min %	Midline Right Slope (%/min)
Bozeman, MT	Alkabo	<b>2.0</b>	3.8	57.1	15.5	168.1	7.0	-2.8
Bozeman, MT	Carpio	<b>8.0</b>	4.6	<b>71.4</b>	<b>33.6</b>	240.3	<b>22.4</b>	-2.0
Bozeman, MT	Divide	4.0	4.1	56.9	<b>15.2</b>	182.2	9.5	-1.6
Bozeman, MT	Grenora	4.0	3.6	59.9	15.3	163.7	7.3	-4.5
Bozeman, MT	Joppa	7.0	4.1	63.8	29.1	181.1	12.1	-2.1
Bozeman, MT	Mountrail	3.0	<b>2.5</b>	64.9	17.8	<b>113.2</b>	<b>3.3</b>	<b>-6.5</b>
Bozeman, MT	MT101694	3.0	3.4	62.1	22.2	155.1	5.4	-3.4
Bozeman, MT	MT101717	5.0	5.3	56.3	17.0	239.8	9.7	<b>-0.1</b>
Bozeman, MT	MT112219	6.0	4.5	52.9	17.8	184.4	13.4	-0.8
Bozeman, MT	MT112434	6.0	5.6	<b>51.0</b>	17.9	231.1	15.5	-0.4
Bozeman, MT	MT112444	6.0	<b>6.7</b>	52.3	15.9	<b>296.6</b>	15.9	-0.4
Bozeman, MT	MT112463	6.0	4.1	54.2	21.6	177.7	11.4	-0.3
Bozeman, MT	Silver	6.0	4.7	58.7	24.3	207.2	14.0	-0.7
Bozeman, MT	Tioga	4.0	4.1	61.6	15.7	193.2	7.0	-2.8
Conrad, MT	Alkabo	7.0	3.0	65.0	24.1	144.4	11.2	-0.6
Conrad, MT	Carpio	<b>8.0</b>	4.2	64.1	27.0	<b>204.4</b>	<b>20.9</b>	-2.3
Conrad, MT	Divide	7.0	3.4	64.7	26.2	156.2	14.6	-2.9
Conrad, MT	Grenora	7.0	3.0	66.7	27.1	142.7	11.8	-1.5
Conrad, MT	Joppa	<b>8.0</b>	3.8	64.9	29.4	175.1	20.0	-1.4
Conrad, MT	Mountrail	<b>3.0</b>	2.9	<b>69.2</b>	26.1	144.5	<b>3.8</b>	<b>-6.1</b>
Conrad, MT	MT101694	5.0	<b>2.8</b>	66.4	25.0	<b>133.7</b>	7.9	-5.1
Conrad, MT	MT101717	6.0	3.2	<b>58.2</b>	<b>22.0</b>	136.3	9.9	-0.7
Conrad, MT	MT112219	7.0	4.3	60.4	23.0	193.3	19.5	-1.3
Conrad, MT	MT112434	<b>8.0</b>	4.2	62.0	27.7	193.8	19.7	<b>-0.1</b>
Conrad, MT	MT112444	7.0	<b>4.4</b>	59.1	26.3	197.4	17.8	-1.0
Conrad, MT	MT112463	<b>8.0</b>	3.6	65.4	<b>32.4</b>	172.6	16.2	-3.9
Conrad, MT	Silver	<b>8.0</b>	3.9	59.3	24.8	174.4	19.3	-0.8
Conrad, MT	Tioga	<b>8.0</b>	3.4	66.2	26.6	165.2	19.4	-2.4
Havre, MT	Alkabo	<b>8.0</b>	3.2	<b>76.2</b>	25.0	176.6	21.0	-2.1
Havre, MT	Carpio	<b>8.0</b>	4.1	70.1	30.8	199.9	<b>22.9</b>	-1.9
Havre, MT	Divide	<b>8.0</b>	3.5	71.5	26.3	178.2	14.0	-3.5
Havre, MT	Grenora	7.0	3.5	68.2	25.9	169.6	12.1	<b>0.2</b>
Havre, MT	Joppa	<b>8.0</b>	3.9	69.8	30.0	196.2	17.8	-3.8
Havre, MT	Mountrail	<b>3.0</b>	<b>2.8</b>	74.0	21.2	<b>148.2</b>	<b>4.6</b>	<b>-6.8</b>
Havre, MT	MT101694	<b>3.0</b>	3.2	66.6	<b>19.9</b>	150.8	6.6	-4.9
Havre, MT	MT101717	6.0	3.6	59.7	22.2	158.0	10.3	-0.4
Havre, MT	MT112219	7.0	5.2	61.1	22.1	234.7	22.3	-1.6
Havre, MT	MT112434	7.0	<b>6.6</b>	<b>53.7</b>	21.8	<b>292.7</b>	20.5	-1.2
Havre, MT	MT112444	7.0	5.9	57.6	21.7	270.2	18.9	-1.3
Havre, MT	MT112463	7.0	4.0	64.6	23.7	192.7	21.6	-2.8
Havre, MT	Silver	7.0	4.6	58.9	20.9	210.1	16.2	-1.0
Havre, MT	Tioga	<b>8.0</b>	3.9	70.4	<b>32.2</b>	191.2	18.7	-3.1

**-bolded data represent the highest and lowest values for each trait.**

**Table 17. CARC, EARC, and WREC mixograph data.**

Location	Line	Mixograph pattern	Midline Peak Time (min)	Midline Peak Value %	Midline Peak Width %	Midline Peak Integral %TQ*min	Bandwidth at 8 min %	Midline Right Slope (%/min)
Moccasin, MT	Alkabo	7.0	3.1	60.6	<b>25.5</b>	137.9	11.4	-3.7
Moccasin, MT	Carpio	<b>8.0</b>	<b>5.5</b>	66.9	32.8	<b>290.6</b>	25.7	-3.4
Moccasin, MT	Divide	7.0	3.5	61.3	31.1	152.5	11.0	-2.5
Moccasin, MT	Grenora	6.0	3.1	61.6	27.6	136.8	8.9	-4.6
Moccasin, MT	Joppa	<b>8.0</b>	4.5	64.7	37.5	211.0	23.8	-1.1
Moccasin, MT	Mountrail	<b>3.0</b>	<b>2.4</b>	<b>70.2</b>	28.8	<b>112.1</b>	<b>6.0</b>	<b>-5.8</b>
Moccasin, MT	MT101694	6.0	2.9	63.3	33.5	125.7	9.7	-3.9
Moccasin, MT	MT101717	7.0	3.5	58.4	27.1	141.9	15.6	0.7
Moccasin, MT	MT112219	<b>8.0</b>	4.9	<b>55.2</b>	31.7	196.4	<b>33.5</b>	-1.0
Moccasin, MT	MT112434	<b>8.0</b>	4.1	56.8	41.1	168.6	26.2	-0.8
Moccasin, MT	MT112444	<b>8.0</b>	4.4	59.6	32.5	200.3	27.2	0.3
Moccasin, MT	MT112463	<b>8.0</b>	3.0	62.3	<b>43.5</b>	128.1	27.0	<b>7.2</b>
Moccasin, MT	Silver	7.0	4.9	58.5	30.8	223.8	19.9	-3.4
Moccasin, MT	Tioga	<b>8.0</b>	3.9	63.0	31.6	177.4	15.4	-2.4
Sidney, MT	Alkabo	5.0	2.9	55.1	21.9	116.5	6.3	<b>-2.9</b>
Sidney, MT	Carpio	6.0	4.6	52.5	22.2	188.1	16.2	-1.8
Sidney, MT	Divide	6.0	3.9	51.6	24.3	158.8	9.2	-0.2
Sidney, MT	Grenora	5.0	2.8	56.0	<b>32.7</b>	112.8	7.3	-1.7
Sidney, MT	Joppa	5.0	4.2	52.9	22.7	165.6	13.2	-1.4
Sidney, MT	Mountrail	<b>3.0</b>	<b>2.3</b>	55.5	19.7	<b>94.2</b>	<b>2.1</b>	-2.0
Sidney, MT	MT101694	4.0	3.4	51.3	<b>16.0</b>	130.3	6.3	-1.0
Sidney, MT	MT101717	5.0	3.4	<b>47.0</b>	18.9	123.8	14.2	-0.9
Sidney, MT	MT112219	6.0	4.5	51.5	20.6	179.2	16.7	-0.9
Sidney, MT	MT112434	<b>7.0</b>	4.3	52.5	28.9	172.8	<b>17.2</b>	-1.1
Sidney, MT	MT112444	<b>7.0</b>	4.4	52.2	21.2	173.5	16.4	-1.8
Sidney, MT	MT112463	<b>7.0</b>	3.8	<b>57.6</b>	26.1	162.4	15.0	-1.0
Sidney, MT	Silver	6.0	<b>5.0</b>	50.5	19.4	<b>191.2</b>	16.2	<b>-0.2</b>
Sidney, MT	Tioga	5.0	4.0	51.3	20.9	156.6	10.2	-0.6
Williston, ND	Alkabo	6.0	3.4	57.6	25.6	143.7	8.9	-2.1
Williston, ND	Carpio	<b>7.0</b>	4.1	<b>58.6</b>	28.9	179.7	20.2	<b>0.8</b>
Williston, ND	Divide	6.0	4.0	55.0	26.0	164.5	13.5	-0.9
Williston, ND	Grenora	5.0	3.2	54.7	22.1	122.9	10.4	-0.7
Williston, ND	Joppa	6.0	3.7	54.5	27.4	142.2	13.3	0.0
Williston, ND	Mountrail	<b>3.0</b>	<b>2.7</b>	53.4	<b>17.2</b>	<b>100.3</b>	<b>3.0</b>	-2.9
Williston, ND	MT101694	<b>3.0</b>	3.4	51.8	21.6	129.2	6.3	-1.4
Williston, ND	MT101717	4.0	3.7	<b>51.3</b>	18.6	145.4	9.0	-1.9
Williston, ND	MT112219	<b>7.0</b>	4.6	54.8	<b>34.6</b>	181.7	14.6	-1.0
Williston, ND	MT112434	<b>7.0</b>	<b>5.4</b>	51.4	27.5	<b>208.5</b>	<b>27.7</b>	-1.3
Williston, ND	MT112444	<b>7.0</b>	4.6	55.3	31.3	180.4	19.1	-0.6
Williston, ND	MT112463	<b>7.0</b>	4.3	52.9	26.1	170.0	20.4	-2.3
Williston, ND	Silver	<b>7.0</b>	3.9	55.8	34.3	150.7	15.9	-1.1
Williston, ND	Tioga	<b>7.0</b>	4.5	54.4	27.7	188.1	15.8	<b>-3.2</b>

**-bolded data represent the highest and lowest values for each trait.**