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Authors: Burt, A.J., Humphreys, D.G., Mitchell Fetch, J., Green, D., Fetch, T.G., et al.

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AAC Redstar hard red spring wheat

A.J. Burt, D.G. Humphreys, J. Mitchell Fetch, D. Green, T.G. Fetch, B.D. McCallum, J. Menzies, R. Aboukhaddour, M.A. Henriquez, and S. Kumar

Abstract: AAC Redstar is an early maturing, high-yielding hard red spring wheat (*Triticum aestivum* L.) cultivar that is well adapted to the northern Canadian Prairies and eligible for grades of Canada Western Red Spring (CWRS) wheat. Over 3 yr (2016–2018) of testing in the Parkland Wheat Cooperative registration trials, AAC Redstar was 11% higher yielding than AC Splendor, 6% higher than Parata, and 4% higher than Glenn and Carberry. AAC Redstar matured 3 d earlier than Glenn, 2 d earlier than Carberry, and had similar maturity to Parata. AAC Redstar was shorter than all checks except Carberry and had better lodging resistance compared with all the check cultivars in the registration trial. The test weight and thousand-kernel weight of AAC Redstar was rated moderately resistant to *Fusarium* head blight, leaf rust, stripe rust, and common bunt. AAC Redstar had resistant reactions to loose smut and stem rust. AAC Redstar was registered under the CWRS market class.

Key words: Triticum aestivum L., hard red spring wheat, cultivar description, grain yield, protein, early maturity, disease resistance.

Résumé : AAC Redstar est une variété de blé roux vitreux de printemps (*Triticum aestivum* L.) hâtive à rendement élevé, bien acclimatée au nord des Prairies canadiennes. Elle est admissible aux classes du blé roux de printemps de l'Ouest canadien (CWRS — « Canada Western Red Spring »). Au cours des trois années (2016–2018) qu'ont duré les essais d'homologation de la Parkland Wheat Cooperative, le rendement d'AAC Redstar a surpassé celui d'AC Splendor de 11 %, celui de Parata de 6 % et celui de Glenn et de Carberry de 4 %. AAC Redstar parvient à maturité trois jours avant Glenn, deux jours avant Carberry et à peu près en même temps que Parata. La paille d'AAC Redstar est plus courte que celle des autres témoins, sauf Carberry, et a mieux résisté à la verse que les autres cultivars lors des essais d'homologation. AAC Redstar a un poids spécifique et un poids de mille grains similaires à ceux de Carberry. Son grain renferme toutefois 0,2 % moins de protéines. AAC Redstar résiste modérément à la fusariose de l'épi, à la rouille des feuilles, à la rouille jaune et à la carie. La variété affiche aussi une certaine résistance au charbon nu et à la rouille de la tige. AAC Redstar a été homologué pour la classe marchande CWRS. [Traduit par la Rédaction]

Mots-clés : Triticum aestivum L., blé roux vitreux de printemps, description de cultivar, rendement grainier, protéine, précocité, résistance à la maladie.

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A.J. Burt* and D.G. Humphreys. Agriculture and Agri-Food Canada, Ottawa Research and Development Centre, 960 Carling Avenue, Ottawa, ON K1A 3C5, Canada.

J. Mitchell Fetch, D. Green, T.G. Fetch, and S. Kumar.* Brandon Research and Development Centre, Agriculture and Agri-Food Canada, 2701 Grand Valley Road, Brandon, MB R7A 5Y3, Canada.

B.D. McCallum, J. Menzies, and M.A. Henriquez. Morden Research and Development Centre, Agriculture and Agri-Food Canada, 101 Route 100, Morden, MB R6M 1Y5, Canada.

R. Aboukhaddour. Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, 5403 1st Avenue South, Lethbridge, AB T1J 4B1, Canada.

Corresponding author: Santosh Kumar (email: Santosh.Kumar@canada.ca).

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Introduction

The northern regions of the western Canadian Prairies, or Parkland Region, is the eco-climatic zone which stretches from north-eastern British Columbia throughout northern Alberta, northern Saskatchewan, and northern Manitoba. The northern prairies extend north of 51°N latitude in Manitoba, north of 53°N in Saskatchewan, and north of 55°N in Alberta. The northern prairies are also characterized by prevalence of gray to dark gray soil and lower growing degree days (GDD; Porter and Gawith 1999) compared with the brown to black soil type and higher GDD in the southern prairies (DePauw et al. 2011a). The GDD at southern prairie locations such as Brandon (Manitoba) and high (Saskatchewan) are 1456 and 1476 units, whereas the northern prairie locations such as High Level (Alberta) and Grand Prairie (Alberta) have lower GDD values of 1086 and 1208 units, respectively. The mean temperature from April to August is approximately 2 °C lower in northern prairies compared with the southern prairies (DePauw et al. 2011a). The killing frost-free days, calculated as the number of days between the last day prior to 1 July and the first day after 1 July with minimum temperature less than 2.2 °C (Hay and Porter 2006), is generally lower in northern prairies compared with the southern prairies (DePauw et al. 2011a). The northern prairies are best suited to wheat varieties that grow faster and yield more with fewer GDD, fewer killing frost-free days, and lower mean temperature during the growing season. Thus, a focused and targeted breeding effort is required to breed wheat varieties truly suited to the northern prairies. The majority of the wheat acreage in the Parkland Region is in northern Alberta. This region is characterized by an extremely short growing season, long day length, and short cool nights. Disease pressure in the Parkland Region is typically lower than in the Western and Central Prairies, especially for Fusarium head blight (FHB) (Fusarium graminearum Schwabe). Stripe rust (Puccinia striiformis Westend.) is an emerging threat, and seasonally, orange wheat blossom midge (Sitodiplosis mosellana Géhin) pressure can be very high. With recent changes in Canada Western Red Spring (CWRS) gluten strength targets, there is a lot of opportunity for new CWRS varieties to capture space in growers' fields in the Parkland Region with earlymaturing lines that have strong agronomic qualities and good disease resistance. AAC Redstar hard red spring wheat was developed at the Brandon Research and Development Centre (BRDC), Agriculture and Agri-Food Canada (AAFC) in Brandon, MB, Canada. Tested as PT488 and 09B12-FJ2D, AAC Redstar was granted registration No. 8923 from the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency on 7 Feb. 2020. Plant Breeders' Rights application No. 19-829 was accepted for filing on 1 May 2019.

Breeding Methods and Pedigree

AAC Redstar is derived from the 2009 cross AAC Redwater/CDC Plentiful. The female parent, AAC Redwater (Zi et al. 2017) was derived from the cross Harvest/McKenzie//AC Intrepid (DePauw et al. 1999; Graf et al. 2003; Fox et al. 2010). The male parent, CDC Plentiful was selected from the cross BW282/CDC Go. Both parental lines, AAC Redwater and CDC Plentiful, are currently registered cultivars belonging to the CWRS market class. A detailed description of the breeding history, cultivar evaluations, and Breeder Seed development is outlined in Table 1. Briefly, 24 F₁ plants were increased in the greenhouse at the Beaverlodge Research Farm, AB, during winter 2009-2010 under the designation 09B12. Then, 12 F2 bulk plots were grown at the Beaverlodge Research Farm in 2010. Spikes (30) were picked from each F_2 plot and planted as $F_{2:3}$ spike-hills in the 2010-2011 contra-season nursery in Palmerston North, NZ. Five spikes were selected per hill "FJ" and planted as single 1 m spike-rows in the 2011 Beaverlodge hybrid nursery; the $F_{3:4}$ row that gave rise to PT488 was designated 09B12-FJ2. F_{3:4} rows were selected based on plant type, resistance to rusts and common bunt [Tilletia caries (DC.) Tul. & C. Tul.], protein concentration, flour yield, and mixograph testing. Selected rows were increased as 1 m F_{3:5} single rows in Palmerston North, NZ, in winter 2011-2012 and selected for plant type and leaf rust (Puccinia triticina Erikss.) resistance. In 2012, selected F_{3:6} lines were grown as yield plots in a randomized complete block design (RCBD) with 108 entries. Successful lines were based on high yield, early maturity, resistance to lodging, moderate height, acceptable end-use quality (flour yield, falling number, and mixograph), resistance to leaf, stem (Puccinia graminis Pers. f. sp. tritici Eriks. & E. Henn.), and stripe rust, and FHB resistance. Six heads collected from 09B12-FJ2 were grown as 1 m F_{6:7} rows in the Palmerston North, NZ, 2012-2013 contra-season nursery, where the row that became PT488 was designated 09B12-FJ2D and selected to progress to the "F₈ level testing" in 2013. 09B12-FJ2D was tested within an RCBD design with 108 entries, one replication at three locations, and was evaluated in the combined leaf, stem rust, and FHB disease nursery at Brandon, MB. Selections were made on a similar basis as the F_6 generation. This line was subsequently evaluated in the 2014 "ParkA1" test as a 7×7 lattice with two replications at five locations and the 2015 "Parkland B" test as a 5×5 lattice with three replications at seven locations. 09B12-FJ2D was given the designation PT488 and evaluated over 3 yr (2016-2018) in the Parkland Wheat Cooperative registration trial. The variables measured and the operating protocols followed in the registration trial were those approved by the Prairie Recommending Committee for Wheat, Rye and Triticale (http://pgdc.ca/committees_ wrt_pd.html). The check cultivars were AC Splendor

| Table 1. | Population | size and | activities at | each genera | ation leading to | the development | nt of AAC Redsta | ar hard red spring wheat. |
|----------|--------------|-----------|---------------|-------------|-------------------|-----------------|------------------|---------------------------|
| | - op anation | 0100 0110 | activities at | each gener | action reading to | the development | | in mana rea opring wheat |

| Name | Gen. | Year | Activity — Number of lines — Locations |
|-------------|----------------------|-----------|--|
| 09B12 | Fo | 2009 | Final cross made in a growth cabinet at Beaverlodge Research Farm, Beaverlodge AB. |
| 09B12 | F ₁ | 2009–2010 | 24 plants increased in greenhouse at Beaverlodge Research Farm, Beaverlodge, AB. |
| 09B12 | F_2 | 2010 | 12 bulk plots seeded in Beaverlodge (10BVR_F2_125-136); harvested 30 spikes per plot (360 total). |
| 09B12-FJ | F _{2:3} | 2010-2011 | 163 hills planted in Palmerston North, NZ (11PNH_03666-03828). Up to five spikes per hill harvested out of all 163 hills. |
| 09B12-FJ2 | F _{3:4} | 2011 | 815 rows of 09B12 (A1 to FU5) grown as 1 m single rows in Beaverlodge hybrid nursery. Selection for agronomics, seed appearance, resistance to rusts and common bunt, protein concentration, flour yield, and mixograph (FJ2 planted as single row). |
| 09B12-FJ2 | F _{3:5} | 2011–2012 | 156 rows of 09B12 (A1 to FU5) grown as 1 m single rows in Palmerston North, NZ. Selection for agronomics and leaf rust resistance (FJ2 planted as single row). |
| 09B12-FJ2 | F _{3:6} | 2012 | "FJ2" line progressed to "F6" level (PR6FHB4) test. Yield trial; RCBD, one replication at four locations (Beaverlodge, AB; Saskatoon, SK; Melfort, SK; Brandon, MB); agronomic, quality, rust, and FHB nursery testing. Spikes out of plot harvested to send to NZ in F7 generation. |
| 09B12-FJ2D | F _{6:7} | 2012–2013 | Six heads from F6 plot sent to Palmerston North, NZ, as a 1 m row nursery. Selection for agronomics and leaf rust resistance as well as quality parameters from F6 yield plot. |
| 09B12-FJ2D | F _{6:8} | 2013 | Line progressed to "F8" level (PR3F8) test. Yield trial; RCBD, one replication at three locations (Melfort, SK; Saskatoon, SK; Beaverlodge, AB); agronomic, quality, rust, and FHB nursery testing. |
| 09B12-FJ2D | F _{6:9} | 2014 | Line progressed to "A" level (Park A1) test. Yield trial; 7 × 7 lattice with two replications at five locations (Brandon, MB; Saskatoon, SK; Melfort, SK; Beaverlodge, AB; Dawson Creek, BC). |
| 09B12-FJ2D | F _{6:10} | 2015 | Line progressed to "B" level (Park B) test. Yield trial; 5 × 5 lattice with three replications at seven locations (Saskatoon, SK; Melfort, SK; Westlock, AB; Neapolis, AB; Edmonton, AB(1); Edmonton, AB(2); Beaverlodge, AB). |
| PT488 | F _{6:11-13} | 2016–2018 | Line progressed to Parkland "C" registration test. Yield trial; 5 × 6 lattices with three replications all years; 12 locations in 2016 (MB: Roblin, Neepawa; SK: Lake Lenore, Glaslyn, Melfort, Kernen; AB: Beaverlodge, Lacombe, Edmonton, Neapolis; BC: Ft.St. John, Dawson Creek); 11 locations in 2017: Not grown in Dawson Creek; 2017/2018 Neepawa was changed to Dauphin, MB. |
| Breeder See | d Product | ion | |
| PT488 | F _{6:11} | 2016 | Breeder Seed spikes: 250 random spikes were selected from a rogued increase plot grown at Saskatoon, SK. |
| PT488 | F _{6:12} | 2017 | Breeder Seed isolation rows: 250 lines were grown in 1 m rows grown near Brandon, MB with a 100 ft isolation distance from any other wheat; 23 were removed for lack of uniformity. |
| PT488 | F _{6:13} | 2018 | Breeder Seed rows: 15 m rows grown at Indian Head, SK with 10 m isolation distance from other wheat. 227 rows were grown. Lines were rogued for uniformity and seven lines were culled. |

Note: RCBD, randomized complete block design; FHB, Fusarium head blight.

| Tuble 2. There has a offered and the full | Table 2. | Yield (kg·ha ⁻¹ |) of AAC Redstar and | l check cultivars | in the Parkland | Wheat Cooperative | registration trials (| 2016-2018). |
|--|----------|----------------------------|----------------------|-------------------|-----------------|-------------------|-----------------------|-------------|
|--|----------|----------------------------|----------------------|-------------------|-----------------|-------------------|-----------------------|-------------|

| | Zone 1 ^{<i>a</i>} | | | Zone 2 | Zone 2 ^b | | | Zone 3 ^c | | | Overall | | | All sites | |
|-------------------|----------------------------|------|------|--------|---------------------|------|------|---------------------|------|------|---------|------|---------------------|-----------|--|
| | | | | | | | | | | | | | 2016–201 | 8 | |
| Cultivar | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 | kg∙ha ^{−1} | % Chk | |
| Glenn | 4157 | 6271 | 4827 | 4117 | 5216 | 5134 | 5394 | 5480 | 4658 | 4746 | 5513 | 4896 | 5051.5 | 101.6 | |
| AC Splendor | 3727 | 6365 | 3915 | 4140 | 4830 | 4804 | 5061 | 4956 | 4552 | 4533 | 5162 | 4546 | 4765.3 | 95.8 | |
| PT472 | 4793 | _ | _ | 4614 | _ | _ | 5535 | | _ | 5125 | | _ | | | |
| Parata | 4389 | 6563 | 3976 | 4273 | 5370 | 5226 | 5555 | 5249 | 4746 | 4935 | 5543 | 4772 | 4980.3 | 100.2 | |
| Carberry | 4276 | 6478 | 4640 | 4334 | 5106 | 5292 | 5362 | 5546 | 4834 | 4854 | 5553 | 4930 | 5092.0 | 102.4 | |
| AAC Redstar | 4829 | 6315 | 4705 | 4888 | 5217 | 5627 | 6001 | 5798 | 4941 | 5421 | 5693 | 5092 | 5278.6 | 106.2 | |
| Mean of checks | 4268 | 6419 | 4339 | 4295 | 5130 | 5114 | 5381 | 5308 | 4698 | 4839 | 5443 | 4786 | 4972.3 | | |
| LSD $_{0.05}^{d}$ | 480 | 1015 | 545 | 216 | 339 | 512 | 274 | 374 | 355 | 180 | 253 | 278 | 284 | | |
| No. of tests | 2 | 2 | 2 | 4 | 4 | 4 | 6 | 5 | 6 | 12 | 11 | 12 | 35 | | |

Note: % Chk, % of the mean of the checks.

^{*a*}Zone 1 test locations: 2016 — Neepawa, Roblin; 2017 — Dauphin, Roblin; 2018 — Dauphin, Roblin.

^bZone 2 test locations: 2016 — Kernen, Melfort, Lake Lenore, Glaslyn; 2017 — Kernen, Melfort, Lake Lenore, Glaslyn; 2018 — Kernen, Melfort, Lake Lenore, Glaslyn.

^cZone 3 test locations: 2016 — Ft. St. John, Edmonton, Beaverlodge, Lacombe, Neaplois, Dawson Creek; 2017 — Ft. St. John, Edmonton, Beaverlodge, Lacombe, Neaplois; 2018 — Ft. St. John, Dawson Creek, Edmonton, Beaverlodge, Lacombe, Neaplois.

^{*d*}Appropriate least significant difference (LSD) to make comparisons of AAC Redstar to Glenn, AC Splendor, Parata, Carberry, PT472. $P \le 0.05$ includes the appropriate genotype by environment interaction.

| Cultivar | Maturity (d) | Height (cm) | Lodging ^a (1–9) | Test weight (kg⋅hL ⁻¹) | Kernel weight (mg∙kernel ⁻¹) | Protein (%) |
|------------------|--------------|-------------|----------------------------|------------------------------------|--|-------------|
| Glenn | 104 | 94 | 2.1 | 82.2 | 37.6 | 14.9 |
| AC Splendor | 100 | 98 | 3.0 | 78.6 | 38.5 | 15.0 |
| Parata | 100 | 100 | 3.0 | 80.4 | 36.7 | 15.2 |
| Carberry | 102 | 86 | 2.3 | 80.2 | 39.5 | 14.6 |
| AAC Redstar | 101 | 92 | 1.9 | 80.2 | 39.5 | 14.4 |
| Mean of checks | 102 | 93 | 2.6 | 80.4 | 38.1 | 14.9 |
| $LSD_{0.05}^{b}$ | 1.5 | 2.9 | 1 | 0.7 | 0.9 | 0.4 |
| No. of tests | 35 | 35 | 35 | 35 | 35 | 35 |

| Table 3. | Summary of agron | omic traits of AAC R | edstar and check | cultivars in the | e Parkland Wheat | t Cooperative regist | ration trials (2 | 2016-2018) |
|----------|------------------|----------------------|------------------|------------------|------------------|----------------------|------------------|------------|
| | ~ 0 | | | | | 1 0 | ` | , |

^{*a*}Lodging scale: 1 = vertical, 9 = flat.

^bAppropriate least significant difference (LSD) to make comparisons of AAC Redstar to Glenn, AC Splendor, Parata, Carberry. $P \le 0.05$ includes the appropriate genotype by environment interaction.

(Fox et al. 2007), Glenn (Mergoum et al. 2006), Parata (Spaner et al. 2016), Carberry (DePauw et al. 2011b), and in 2016, PT472, an unregistered line from the BRDC, AAFC. The data for the test were analyzed for individual years and combined following a mixed model design in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA), with environments and replications as random effects and genotype as a fixed effect. In the registration trials, the stem rust races were TPMK, TMRT, RHTS, QTHS, RTHJ, RKQS, and MCCF (Fetch et al. 2011). The leaf rust inoculum comprised a mixture of prevalent races isolated from the western Canadian prairies as determined from yearly survey studies (McCallum et al. 2016, 2017). Resistance to races T2, T9, T10, and T39 of loose smut [Ustilago tritici (Pers.) Rostr.] (Menzies et al. 2003) and resistance to a mixture of prevalent races (L1, L16, T1, T6, T13, and T19) of common bunt (Gaudet and Puchalski 1989; Gaudet et al. 1993) were evaluated in the Parkland Wheat Cooperative registration trials. Resistance to FHB was tested using the macroconidial spore suspension (University of Manitoba, Carman, MB) or corn spawn (Morden Research and Development Centre, MB) inoculum. An equal proportion of four isolates (M1-07-2/ 15ADON, M3-07-2/15ADON, M7-07-1/3ADON, and M9-07-1/ 3ADON) of F. graminearum was also evaluated in the Parkland Wheat Cooperative registration trials. End-use quality analyses were conducted at the Grain Research Laboratory, Canadian Grain Commission using approved methods (American Association of Cereal Chemists 2000) each year on composite grain samples from all locations with no serious down-grading factors. End-use quality data from the composite samples of AAC Redstar and check cultivars for each year were used as replicates to estimate least-square means for all quality traits over the 3 yr of testing.

Plant descriptive characteristics were recorded from a three-replicate trial conducted in a RCBD at the AAFC Saskatoon Research Farm in Saskatoon, SK, during 2018 and 2019. This trial included the reference cultivars AAC Redwater and CDC Plentiful. All characteristics were recorded as prescribed in the Objective Description Form of the Variety Registration Office, Canadian Food Inspection Agency.

Performance

Agronomy

Averaged over 35 site-years AAC Redstar was significantly higher yielding than the mean of the checks (P < 0.05), and averaged 11% higher than AC Splendor, 6% higher than Parata, and 4% higher than either Glenn and Carberry (Table 2). AAC Redstar had similar maturity to Parata, was 2 d earlier than Carberry, 3 d earlier than Glenn, and 1 d later than AC Splendor. AAC Redstar was shorter than all checks except Carberry and had a lower mean lodging rating than all the checks (Table 3). Test weight, kernel weight, and whole grain protein concentration were similar to Carberry.

Disease

FHB index and DON accumulation of AAC Redstar were consistently equal to or lower than Carberry (Table 4). AAC Redstar was resistant to the prevalent races of stem rust and loose smut, and moderately resistant to leaf rust, stripe rust, and common bunt (Tables 5 and 6).

End-use quality

AC Redstar was deemed eligible for all grades of the CWRS wheat class. The results of end-use quality testing are summarized in Tables 7 and 8. AAC Redstar had a consistently high falling number and clean wheat flour yield. Grain protein content was within the range of the checks, except in 2018 when it was slightly lower. Dough strength as determined by extensograph was consistently higher than Carberry in all 3 yr of testing (Table 8).

Other traits

These morphological characters were recorded using field plots grown in Saskatoon in 2018 and 2019 and used for registration purposes.

Seedling characteristics

Coleoptile colour: weak anthocyanin expression. *Juvenile growth habit:* semi-erect to intermediate. *Seedling leaves:* medium green, glabrous.

Adult plant characteristics

Growth habit: intermediate.

Flag leaf: medium green, recurved, glabrous sheath and blade, medium length and width, waxy blade.

Culm: straight to slightly curved, glabrous, moderate waxiness.

Spike characteristics

Shape: erect and parallel sided. Length: short. Density: lax to medium dense. Attitude: erect. Colour: amber at maturity. Awns: fully awned.

Spikelet characteristics

Glumes: medium to long and narrow width; slightly pubescent; rounded shoulder shape; beak is short with slight curve.

Lemma: straight.

Kernel characteristics

Type: hard, medium red in colour.

Size: medium size, medium length, medium width; elliptical shape; angular cheeks; short to medium brush hairs; crease with narrow width and medium depth.

Embryo: medium size, oval.

Maintenance and Distribution of Pedigreed Seed

Breeder Seed of AAC Redstar was produced using 250 random spikes from a rogued seed increase plot grown

| | 2016 | | | 2017 | | | 2018 | | |
|-------------|--------------------------|-----|---------|--------------------------|-----|------------------|------------------|-----|------------------|
| Cultivar | V RI ^a | DON | ISD^b | V RI ^a | DON | ISD ^b | VRI ^a | DON | ISD ^b |
| Morden FHB | | | | | | | | | |
| Glenn | 23R | 21 | 15R | 22MR | 11 | 9MR | 20MR | 3MR | 4MR |
| AC Splendor | 56MS | 30 | 21I | 59S | 17 | 13I | 29I | 8I | 7I |
| PT472 | 53MS | 33 | 23MS | _ | _ | _ | _ | _ | — |
| Parata | 39MR | 37 | 25MS | 25MR | 13 | 10MR | 10MR | 2MR | 2MR |
| Carberry | 29MR | 26 | 18MR | 14MR | 12 | 9MR | 13MR | 3MR | 4MR |
| AAC Redstar | 31MR | 25 | 18MR | 26MR | 8 | 7MR | 8MR | 3MR | 3MR |
| Carman FHB | | | | | | | | | |
| Glenn | 11MR | 21 | 14 | 8MR | 7 | 18MR | 17I | 5I | 5I |
| AC Splendor | 17I | 14 | 10 | 59S | 13 | 38MS | 36S | 8MS | 8MS |
| PT472 | 14MR | 44 | 28 | — | | — | _ | | _ |
| Parata | 13MR | 31 | 20 | 20I | 11 | 27I | 20I | 4I | 4I |
| Carberry | 20I | 42 | 27 | 15MR | 10 | 24I | 12MR | 3MR | 3MR |
| AAC Redstar | 14MR | 24 | 16 | 13MR | 9 | 21MR | 5MR | 3MR | 3MR |

Note: Disease rating class: R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible; DON, deoxynivalenol.

^aFHB index: (percentage of infected heads × percentage of diseased florets on infected heads)/100.

^bISD = visual incidence + visual severity + DON = $(0.2 \times \text{mean incidence} + 0.2 \times \text{mean severity} + 0.6 \times \text{mean DON})$.

| Table 5. | Rust disease severities and ratings of A | C Redstar and check cultiva | ars in the Parkland Wheat | Cooperative registration | trials (2016–2018) |
|----------|--|-----------------------------|---------------------------|--------------------------|--------------------|
|----------|--|-----------------------------|---------------------------|--------------------------|--------------------|

| | Leaf rust ^a (Morden, MB) | | | Stem rust ^b (Brandon, MB) | | | Stripe rust ^c (Creston, BC) | | Stripe rust (Lethbridge, AB) | | | |
|-------------|-------------------------------------|------|------|--------------------------------------|------|------|---|------|------------------------------|------|----------|----------|
| Cultivar | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 | 2016 | 2017 | 2016 | 2017 | 2018 (1) | 2018 (2) |
| Glenn | 28MR | 27MR | 1MR | 10R | 10MR | 5MR | 25I | 1R | 15MR | 40MS | 20I | 7R |
| AC Splendor | 32MR | 30MR | 1I | 5R | 5R | 2MR | 85S | 20MR | 45MS | 80S | 85S | 30I |
| PT472 | | _ | _ | 20MR | _ | _ | 25I | _ | 10MR | | _ | |
| Parata | 2MR | 6R | 1R | 5R | 5R | 5MR | 5R | 1R | 15MR | 15MR | 60S | 25I |
| Carberry | 4MR | 1R | 1R | 5R | 10MR | 5MR | 5R | 1R | 10MR | TR | 10MR | 2R |
| AAC Redstar | 12MR | 13MR | 1R | 7MR | 5R | 1R | 25I | 1R | 10MR | 2R | 1R | 2R |

Note: Disease rating class: R, resistant (1%-10%); MR, moderately resistant (11%-30%); I, intermediate (31%-39%); MS, moderately susceptible (40%-60%); S, susceptible (>60%). Disease response category: R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.

^aSeverity is the percentage of leaf/stem area affected by rust. Reaction is the descriptive classification of disease based on percent severity.

^bSeverity is the percentage of stem infected with stem rust using the Modified Cobb Scale.

^cSeverity is the percentage of leaf area affected by rust. Dominant pustule reaction for stripe rust.

| | Common bunt ^a (Lethbridge, AB) | | | Loose smut ^b | | | Leaf spots ^c (Melfort, SK) | | | Leaf spots ^c (Swift Current, SK) | | |
|-------------|--|------|------|-------------------------|------|------|--|------|------|--|------|------|
| Cultivar | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 |
| Glenn | 3R | 15I | 4R | 0R | _ | 34MR | 8.0I | 2.3 | 2.7 | 10S | _ | |
| AC Splendor | 10MR | 4MR | 10MR | 5R | | 17MR | 8.3MS | 2.7 | 3.3 | 10S | | |
| PT472 | 6MR | | | | | | 8.7MS | _ | | 10S | | |
| Parata | 4MR | OR | OR | OR | _ | 38I | 10.3S | 5.7 | 3.0 | 10S | _ | |
| Carberry | 2R | 1MR | OR | OR | | OR | 10.7S | 3.0 | 3.3 | 10S | | |
| AAC Redstar | OR | 3MR | OR | OR | | 8R | 11.0S | 2.7 | 4.0 | 10S | | |

Table 6. Bunt, smut, and leaf spot of AAC Redstar and check cultivars in the Parkland Wheat Cooperative registration trials (2016–2018).

Note: Midge data were not collected as both parents are susceptible to orange blossom wheat midge. Disease rating class: R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.

^aBunt data represented as severity (percentage of heads with bunt symptoms) and ratings.

^bLoose smut data represented as severity (percentage of plants with loose smut symptoms) and ratings.

^cLeaf spot data represented as severity (percentage of leaves with leaf spot symptoms) and ratings.

| | Flour charac | teristics | | | Milling performance | | | | | |
|---------------------|----------------------|----------------------|---------------------|-----------------------|---------------------|---|--------------------------------|---------------|----------------------|--|
| Cultivar | Grain protein (%) | Flour protein (%) | Protein loss (%) | Falling number (s) | Amylo-graph (BU) | Clean wheat flour yield (%) ^a | Flour yield (0.50% ash) (%) | Flour ash (%) | Starch damage (%) | |
| 2016 | | | | | | | | | | |
| Glenn | 14.1 | 13.1 | 0.9 | 310 | 480 | 74.8 | 77.5 | 0.43 | 8.6 | |
| AC Splendor | 15.3 | 14.3 | 0.9 | 385 | 520 | 75.9 | 75.5 | 0.47 | 6.4 | |
| PT472 | 14.6 | 13.9 | 0.7 | 465 | 660 | 76.8 | 79.5 | 0.39 | 6.3 | |
| Parata | 14.9 | 14 | 0.8 | 475 | 575 | 75.7 | 77.5 | 0.43 | 7.2 | |
| Carberry | 14.1 | 13.2 | 0.9 | 330 | 345 | 75.4 | 78 | 0.42 | 7.4 | |
| AAC Redstar 2017 | 14.4 | 13.7 | 0.7 | 435 | 650 | 78.2 | 78.5 | 0.41 | 6.5 | |
| Glenn | 14.4 | 13.6 | 0.8 | 360 | 725 | 75.3 | 79.0 | 0.40 | 8.4 | |
| AC Splendor | 14.7 | 13.9 | 0.8 | 395 | 590 | 76.2 | 78.0 | 0.42 | 6.8 | |
| Parata | 14.0 | 13.4 | 0.6 | 400 | 570 | 76.8 | 79.0 | 0.40 | 7.6 | |
| Carberry | 14.4 | 13.4 | 0.9 | 380 | 520 | 75.9 | 78.5 | 0.41 | 7.9 | |
| AAC Redstar 2018 | 14.0 | 13.4 | 0.6 | 430 | 695 | 77.2 | 79.0 | 0.40 | 7.0 | |
| Glenn | 15.0 | 14.2 | 0.8 | 400 | 785 | 75.7 | 78.5 | 0.41 | 8.3 | |

Table 7. Wheat and flour analytical data for AAC Redstar and check cultivars from the Parkland Wheat Cooperative registration trials (2016–2018).

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| | Flour charact | eristics | | | Milling performance | | | | | |
|-------------|----------------------|----------------------|---------------------|-----------------------|---------------------|---|--------------------------------|---------------|----------------------|--|
| Cultivar | Grain protein (%) | Flour protein (%) | Protein loss (%) | Falling number (s) | Amylo-graph (BU) | Clean wheat flour yield (%) ^a | Flour yield (0.50% ash) (%) | Flour ash (%) | Starch damage (%) | |
| AC Splendor | 15.3 | 14.4 | 0.9 | 430 | 580 | 76.4 | 78.0 | 0.42 | 6.8 | |
| Parata | 15.3 | 14.4 | 0.9 | 460 | 730 | 77.2 | 78.5 | 0.41 | 7.0 | |
| Carberry | 15.2 | 14.1 | 1.0 | 405 | 555 | 76.1 | 77.5 | 0.43 | 7.5 | |
| AAC Redstar | 14.6 | 14.0 | 0.7 | 525 | 715 | 77.8 | 78.5 | 0.41 | 6.6 | |

Note: End-use quality testing was performed by the Grain Research Lab of the Canadian Grain Commission on a composite sample of each cultivar. The American Association of Cereal Chemists methods were followed by the Grain Research Laboratory, Canadian Grain Commission for determining the various end-use quality traits on a composite of 6–10 locations each year.

^aDexter and Tipples (1987). All millings at the Grain Research Laboratory, Canadian Grain Commission are performed in rooms with environmental control maintained at 21 °C and at 60% relative humidity. Common wheat is milled on an Allis–Chalmers laboratory mill using the GRL sifter flow as described by Black et al. (1980). Flour yield is expressed as a percentage of cleaned wheat on a constant moisture basis.

Table 8. Dough properties and baking qualities for AAC Redstar and check cultivars from the Parkland Wheat Cooperative registration trials (2016–2018).

| | Dough pr | operties | | | | | Baking q | uality | | | |
|---------------------|----------------------|---------------------------|---|--------------|--------------------------|---------------|----------------------------------|----------------------|--|--------------------------------------|-------------------|
| | Farinogra | ph | | Extensograph | | | Lean no time ^{<i>a</i>} | | | | |
| Cultivar | Abs (%) ^b | DDT (min) ^c | MTI (BU) ^d stability (min) | EXT area | EXT R _{ma} x | EXT length | Abs (%) | Mixing time (min) | Mixing energy (Wh∙kg ⁻¹) | Loaf volume (cm ³) | Loaf top ratio |
| 2016 | | | | | | | | | | | |
| Glenn | 65.9 | 5.00 | 10.5 | 155 | 710 | 18.4 | 74 | 4.3 | 11.9 | 905 | 0.71 |
| AC Splendor | 65.6 | 6.25 | 10.0 | 127 | 563 | 19.1 | 72 | 3.6 | 11.3 | 795 | 0.56 |
| PT472 | 64.8 | 6.75 | 9.5 | 124 | 502 | 20.0 | 73 | 3.0 | 8.9 | 815 | 0.55 |
| Parata | 65.4 | 7.25 | 9.5 | 128 | 499 | 20.9 | 72 | 3.2 | 9.5 | 825 | 0.54 |
| Carberry | 64.4 | 5.50 | 6.5 | 93 | 378 | 19.7 | 71 | 3.3 | 9.0 | 785 | 0.56 |
| AAC Redstar 2017 | 65.3 | 7.50 | 11.5 | 156 | 612 | 20.9 | 72 | 3.2 | 9.8 | 805 | 0.57 |
| Glenn | 66.9 | 8.25 | 9.5 | 127 | 547 | 18.7 | 74 | 3.9 | 10.2 | 870 | 0.61 |
| AC Splendor | 65.7 | 6.75 | 10.0 | 113 | 431 | 20.8 | 73 | 2.8 | 8.3 | 815 | 0.50 |
| Parata | 64.4 | 7.75 | 10.0 | 106 | 472 | 18.3 | 71 | 3.4 | 8.6 | 775 | 0.46 |

| | Dough pr | operties | | | | | Baking qı | uality | | | |
|--|------------------|--------------------|------------------------------------|-----------|-----------|-------------|-----------|------------------|----------------------|-----------------|-----------|
| | Farinogra | hh | | Extense | ograph | | Lean no t | ime ^a | | | |
| | 1 | DDT | MTI (BU) ^d stability | EXT | EXT | EXT | | Mixing | Mixing energy | Loaf volume | Loaf |
| Cultivar | Abs $(\%)^{\nu}$ | (min) ^c | (min) | area | $R_{ma}X$ | length | Abs (%) | time (min) | $(Wh \cdot kg^{-1})$ | (cm^3) | top ratio |
| Carberry | 64.9 | 5.50 | 5.5 | 94 | 354 | 20.7 | 72 | 2.9 | 7.7 | 770 | 0.49 |
| AAC Redstar | 65.2 | 7.00 | 10.0 | 117 | 474 | 19.8 | 72 | 3.0 | 7.9 | 750 | 0.49 |
| 2018 | | | | | | | | | | | |
| Glenn | 67.1 | 9.75 | 11.0 | 151 | 664 | 19.1 | 74 | 3.9 | 10.8 | 840 | 0.56 |
| AC Splendor | 66.1 | 7.25 | 8.5 | 98 | 412 | 18.5 | 73 | 2.8 | 8.3 | 770 | 0.41 |
| Parata | 66.3 | 7.5 | 11.0 | 107 | 445 | 19.1 | 73 | 3.3 | 9.0 | 770 | 0.43 |
| Carberry | 66.3 | 6.25 | 7.0 | 94 | 371 | 20.0 | 73 | 3.3 | 10.0 | 745 | 0.45 |
| AAC Redstar | 66.4 | 6.50 | 11.5 | 129 | 544 | 19.0 | 73 | 3.2 | 9.8 | 795 | 0.53 |
| ^a Dupuis and | Fu (2016). | | | | | | | | | | |
| ^{b} Abs: Farinog | raph Absorp | tion. Amer | ican Associatio | n of Cere | al Chemis | sts (2002). | | | | | |
| ^c DDT: Farino | graph Dough | Developm | ent Time meas | ured in m | iinutes. | | | | | | |

at Saskatoon, SK, in 2016. These spikes were grown as an isolated group of 1 m single spike-rows in 2017 in Brandon, MB; 23 lines were rejected for lack of uniformity. In 2018, 227 pre-breeder seed rows were grown at the Seed Increase Unit, Indian Head, SK; each 15 m length row was rogued for uniformity, and seven rows were discarded. The remaining rows were inspected and harvested in bulk, producing 265 kg of Breeder Seed. Multiplication; distribution of all other pedigreed seed classes will be handled by SeCan, 400-300 Terry Fox Dr., Kanata, ON K2K 0E3, Canada (https://www.secan.com/).

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MTT: Farinograph Mixing Tolerance Index expressed in Brabender Units (BU)

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