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Canadian Journal of Plant Science

Cultivar description

# Donalda hard red spring wheat

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## Abstract

Donalda, a hard red spring wheat (*Triticum aestivum* L.), was developed at the University of Alberta, Edmonton, Canada. It is an awned, hollow-stemmed cultivar with high yield potential, short in stature with good lodging tolerance. During the 3 years of testing in the Western Bread Wheat Registration tests during 2018–2020, Donalda yielded 4.3% higher than Carberry and displayed similar physiological maturity. Additional features of Donalda that paralleled the performance of Carberry included plant height, tolerance to lodging, and quality parameters related to test weight, grain weight, and grain protein content. Overall, during the 3 years of testing, Donalda was rated "resistant" to the prevalent races of leaf, stem, and stripe rusts, "moderately susceptible" to common bunt and "intermediate" to *Fusarium* head blight. Three years of the end-use quality evaluation indicated that Donalda met the quality guidelines for the Canada Western Red Spring wheat market class.

**Key words:** *Triticum aestivum* L., Canada Western Red Spring, rust resistance, *Fusarium* head blight resistance, lodging tolerance

## Résumé

La variété de blé roux vitreux de printemps (*Triticum aestivum* L.) Donalda a été créée à l'Université de l'Alberta, à Edmonton (Canada). Ce cultivar barbu de courte taille, à tige creuse, se caractérise par un rendement potentiel élevé. La variété résiste bien à la verse. Au cours des trois années qu'ont duré les essais d'homologation du blé panifiable de l'Ouest (de 2018 à 2020), Donalda a enregistré un rendement de 4,3 % plus élevé que celui de Carberry à une maturité physiologique analogue. Parmi les autres particularités de Donalda correspondant à celles de Carberry, mentionnons la taille du plant, la tolérance à la verse et les paramètres qualitatifs (poids spécifique, poids du grain et teneur en protéines du grain). Dans l'ensemble, au cours des trois années d'essai, la variété Donalda a été qualifiée de « résistante » aux races prévalentes de la rouille des feuilles, de la rouille de la tige et de la rouille jaune, de « modérément sensible » à la carie et de « moyennement résistante » à la fusariose de l'épi. L'évaluation triennale de la qualité du cultivar en regard de son usage final correspond aux valeurs de la classe marchande « blé roux de printemps de l'Ouest canadien ». [Traduit par la Rédaction]

**Mots-clés :** *Triticum aestivum* L., blé roux de printemps de l'Ouest canadien, résistance à la rouille, résistance à la fusariose de l'épi, tolérance à la verse

## Introduction

Donalda, a hard red spring wheat (*Triticum aestivum* L.) cultivar well adapted to the wheat growing regions of western Canada, was developed at the University of Alberta, Edmonton, AB, Canada. Donalda is a medium-maturing, high-yielding cultivar with good lodging tolerance. It has end-use quality suitable for the Canada Western Red Spring (CWRS) market class and was accepted to the Canadian Grain Commission CWRS variety designation list (https://www.grainscanada.gc.ca/en/grain-quality/variety-lists/2021/2021-18.html). It has good resistance against leaf, stem, and stripe rusts and displayed intermediate resistance against *Fusarium* head blight (FHB). Donalda was issued registration no. 9497 by the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency on 28 January 2022.

## Pedigree and breeding method

Donalda derives from the cross Peace/Carberry made at the University of Alberta in 2011. The $F_1$ seed was planted in the field and harvested in bulk. The $F_2$ seed was planted in 50 m long row in Edmonton in 2012. Two hundred heads were randomly selected from the row and bulked. The bulked $F_3$ seed was planted in New Zealand in 2012–2013 in long rows, and 220 heads were randomly picked at harvest. One seed from the 220 $F_4$ heads was separately planted in a greenhouse in Edmonton and advanced to $F_6$ generation through two cycles



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**Table 1.** Least squares means for agronomic traits of Donalda and check cultivars in the Western Bread Wheat Cooperative test, 2018–2020.

| Cultivar | Yield ($kg\,ha^{-1}$) | Yield (%Chk)[a] | Maturity (days) | Height (cm) | Lodging (1–9)[b] | Test weight ($kg\,hL^{-1}$) | Grain weight ($g\,1000^{-1}$) | NIRS protein (%) |
|---|---|---|---|---|---|---|---|---|
| Carberry | 4093 | 96.0 | 98.9 | 80.8 | 1.8 | 813 | 35.0 | 14.7 |
| Glenn | 4054 | 95.1 | 98.4 | 87.6 | 2.2 | 834 | 33.9 | 14.5 |
| AAC Viewfield | 4643 | 108.9 | 99.2 | 78.4 | 2.7 | 82.1 | 33.5 | 14.0 |
| **Donalda** | **4238** | **99.4** | **98.7** | **83.0** | **2.0** | **81.3** | **34.1** | **14.8** |
| LSD[c] (0.05) | 229 | | 1.3 | 3.6 | 1.3 | 0.8 | 1.8 | 0.4 |
| No. of environments | 38 | | 36 | 37 | 7 | 38 | 38 | 38 |

[a]Percent of mean of checks.
[b]1 = no lodging (erect); 9 = completely lodged (flat).
[c]Least significant difference.

of the single seed descent method. The $F_6$ heads were planted as head rows in Edmonton in 2014, and 48 rows were selected based on plant height, maturity, and rust resistance. The selected $F_7$ heads were grown as a 2 m row in New Zealand in 2014–2015 and 42 rows were selected based on rust resistance, plant height, and maturity. The 42 $F_8$ lines were tested in unreplicated preliminary yield trials in 3 m × 1.14 m plots in Edmonton and in leaf rust, bunt, and leaf spot nurseries in Edmonton and stripe rust nurseries in Lethbridge and Creston in 2015. Based on agronomic, disease, and end-use quality data, a line UAW1131*F8SSD080 was selected and subsequently evaluated in replicated multilocation advanced yield trials in 2016. This line was further evaluated in the Parkland B test as entry number 8 in 2017 and as BW5065 in the Western Bread Wheat Cooperative test in 2018, 2019, and 2020.

Donalda and check cultivars were evaluated in the Western Bread Wheat Cooperative tests for agronomic, disease resistance, and end-use quality traits following protocols described in the operating procedures of the Prairie Recommending Committee for Wheat, Rye, and Triticale (PRCWRT) (Anonymous 2020). Agronomic performance was assessed in multi-environment trials conducted from 2018 to 2020 in 38 environments across the three Prairie provinces of Alberta, Manitoba, and Saskatchewan. The trials were laid out in a rectangular lattice design with three replications per environment. The agronomic data for the test were analysed for individual years and combined in a mixed model design in SAS software version 9.4 (SAS Institute Inc. 2013), with environment and replication as random effects and genotype as a fixed effect. Response to stem rust (*Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks. & E. Henn.) was assessed at the seedling stage and in the field using stem rust races QTHJF, RKQSC, RHTSC, RTHJF, TMRTF, and TPMKC (Fetch et al. 2021). For leaf rust (*Puccinia triticina* Eriks.) assessment, representative leaf rust races from previous years were used at seedling and adult plant stages (McCallum et al. 2020). Field evaluation of leaf and stem rust was conducted annually in epiphytotic nurseries in Morden and Brandon, MB, respectively. Reaction to stripe rust (*Puccinia striiformis* Westend.) was evaluated in natural stripe rust nurseries in Lethbridge, AB (Randhawa et al. 2012). Resistance to FHB (*Fusarium graminearum* Schwabe; teleomorph *Gibberella zeae* (Schwein.) Petch) was assessed by inoculating field nurseries at Carman and Morden, MB, with a macroconidial suspension (Gilbert and Woods 2006). Response to common bunt was evaluated by inoculating seed with a mixture of prevalent races L1, L16, T1, T6, T13, and T19 of common bunt and planting in mid-April of each year in Lethbridge, AB, following protocols of Gaudet and Puchalski (1989). Loose smut resistance was evaluated by injecting prevalent races T2, T9, T10, and T39 of *Ustilago tritici* (Pers.) Rostr into the florets of plants at anthesis in the field and growing and rating the inoculated seed in the greenhouse (Menzies et al. 2003). All the disease resistance evaluation protocols are described in Appendix E of the PRCWRT operating procedures (Anonymous 2020).

End-use quality analyses were done at the Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, following standard protocols of the American Association of Cereal Chemists (AACC 2000). The Canadian Grain Commission first determined the grain grade and protein concentration for the check cultivars at all test locations and then devised a common site-blending formula for the checks and candidate cultivars to develop composite samples. The composites did not include grain samples from test locations with severe downgrading factors. Quality data were analysed in the Mixed Procedure of SAS software version 9.4 (SAS Institute Inc. 2013), considering year as replication.

Plant descriptive characteristics were recorded from a three-replicate trial conducted in a randomized complete block design at the University of Alberta Research Farm, Edmonton, Canada, between 2020 and 2021. This trial included the reference cultivars AAC Viewfield (Cuthbert et al. 2019), Cardale (Fox et al. 2013), and Carberry (DePauw et al. 2011). All characteristics were recorded following the guidelines in the objective description form of the Variety Registration Office, Canadian Food Inspection Agency.

## Performance

During the 3 years (2018–2020) of testing in the Western Bread Wheat Registration test, Donalda yielded 3.4% and 4.3% higher than Carberry and Glenn, respectively, but 9.5% lower than AAC Viewfield with a similar maturity to the checks (Table 1). Donalda (83.0 cm) had 4.6 cm shorter


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**Table 2.** Reaction of Donalda to stripe, stem, and leaf rusts, common bunt, and loose smut in Western Bread Wheat Cooperative test, 2018–2020.

| | | | | Stem rust | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Stripe rust | | Morden | | Brandon | | Leaf rust | | Common bunt | | Loose smut[c] | |
| Year | Entry | Severity[a] | Rate[b] | Severity | Rate | Severity | IR | Severity | Rate | Mean | Rate | % infection[d] | Rate |
| 2018 | Carberry | 3 | R | 1 | R | 10 | MR | 0.3 | R | 0 | R | 4 | R |
| 2019 | Carberry | 23 | MR | 1 | R | 5 | R | 9.3 | R | 3 | R | – | – |
| 2020 | Carberry | 15 | MR | 1 | R | – | – | 4.0 | R | – | – | – | – |
| 2018 | Glenn | 12.5 | MR | 1 | R | 10 | MR | 3.7 | R | 4.0 | R | 17 | MR |
| 2019 | Glenn | 43 | MS | 1 | R | 10 | R | 48.3 | MS | 10 | MR | – | – |
| 2020 | Glenn | 40 | I | 1 | R | – | – | 25.0 | MR | – | – | – | – |
| 2018 | Viewfield | 12.5 | MR | 1 | R | 10 | MR | 1.7 | R | 7.5 | MR | 59 | MS |
| 2019 | Viewfield | 50 | S | 1 | R | 10 | R | 28.3 | MR | 0 | R | – | – |
| 2020 | Viewfield | 20 | MR | 1 | R | – | – | 30.0 | MR | – | – | – | – |
| 2018 | **Donalda** | **1** | **R** | **1** | **R** | **5** | **R** | **3.3** | **R** | **35** | **MS** | **10** | **R** |
| 2019 | **Donalda** | **10** | **R** | **1** | **R** | **5** | **R** | **16.7** | **MR** | **20** | **MR** | – | – |
| 2020 | **Donalda** | **15** | **MR** | **1** | **R** | – | – | **5.0** | **R** | – | – | – | – |

[a]Severity (%).
[b]R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.
[c]Loose smut nursery was grown in 2018 only.
[d]Percent infection.

**Table 3.** Reaction of Donalda to *Fusarium* head blight in Western Bread Wheat Cooperative test, 2018–2020.

| | | Morden | | | | | | Carmen | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Entry | Mean INC[a] | Mean SEV[b] | VRI[c] | VRI Rate[d] | DON[e] (ppm) | DON Rate | Mean INC | Mean SEV | VRI | VRI Rate | FDK[f] (%) | DON (ppm) | DON Rate |
| 2018 | Carberry | 5.8 | 2.7 | 15.7 | MR | 4.3 | MR | 4.5 | 1.7 | 7.2 | MR | 0.9 | 3.2 | MR |
| 2019 | Carberry | 7.5 | 3.3 | 25.1 | MR | 7.9 | MR | 7.0 | 1.5 | 10.6 | MR | 3.0 | 5.2 | MR |
| 2020 | Carberry | 6.3 | 2.7 | 17.3 | I | 18.3 | I | 8.2 | 4.3 | 35.3 | I | 4.4 | 10.7 | I |
| 2018 | Glenn | 5.7 | 3.5 | 20.2 | I | 5.4 | MR | 4.8 | 1.8 | 9.0 | MR | 0.9 | 3.0 | MR |
| 2019 | Glenn | 8.0 | 4.0 | 31.8 | I | 6.6 | MR | 7.8 | 2.2 | 14.4 | MR | 5.5 | 9.2 | I |
| 2020 | Glenn | 6.7 | 2.7 | 17.2 | I | 14.7 | I | 7.0 | 3.3 | 23.8 | I | 2.9 | 8.9 | I |
| 2018 | AAC Viewfield | 7.0 | 3.3 | 23.5 | I | 4.3 | MR | 6.0 | 1.8 | 11.4 | MR | 0.7 | 5.4 | I |
| 2019 | AAC Viewfield | 8.3 | 4.0 | 33.3 | I | 12.2 | I | 8.5 | 2.8 | 24.1 | I | 6.7 | 12.3 | I |
| 2020 | AAC Viewfield | 5.7 | 2.8 | 16.3 | I | 22.9 | MS | 8.5 | 4.7 | 39.7 | I | 2.8 | 10.2 | I |
| **2018** | **Donalda** | **4.2** | **1.7** | **6.8** | **MR** | **4.3** | **MR** | **4.8** | **1.2** | **5.8** | **MR** | **1.6** | **4.8** | **I** |
| **2019** | **Donalda** | **7.5** | **3.5** | **26.3** | **I** | **7.1** | **MR** | **7.2** | **2.0** | **14.3** | **MR** | **5.0** | **8.2** | **I** |
| **2020** | **Donalda** | **4.8** | **2.2** | **10.4** | **MR** | **17.9** | **I** | **7.3** | **2.0** | **14.6** | **MR** | **1.6** | **6.5** | **MR** |

[a]Incidence.
[b]Severity.
[c]Visual rating index = ((R1inc∗R1sev) + (R2inc∗R2sev) + (R3inc∗R3sev))/3.
[d]R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.
[e]Deoxynivalenol.
[f]*Fusarium* damaged kernels.

plants than Glenn, was similar to Carberry, and 4.6 cm taller than AAC Viewfield (Table 1). The lodging score of Donalda (2.0) was similar to the checks. The test weight of Donalda (81.3 kg hL$^{-1}$) was similar to Carberry (81.3 kg hL$^{-1}$) but lower than Glenn (83.4 kg hL$^{-1}$) and AAC Viewfield (82.1 kg hL$^{-1}$) (Table 1). The thousand kernel weight of Donalda (34.1 g) was similar to Glenn (33.9 g), Carberry (35.0 g), and AAC Viewfield (33.5 g). The grain protein concentration, as determined


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**Table 4.** Least squares means of end-use quality traits for Donalda and checks in Western Bread Wheat Cooperative test, 2018–2020.

| Cultivar | Wheat and flour characteristics | | | | | Milling performance | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Grain protein (%) | Flour protein (%) | Protein loss (%) | Falling number (s) | Amylograph peak viscosity (BU) | Clean flour yield | Flour yield PB 0.50 ash | Flour ash (%) | Starch damage (mega-zeme) |
| Carberry | 15.0 | 14.1 | 0.93 | 385.0 | 513.3 | 76.2 | 78.0 | 0.42 | 7.5 |
| Glenn | 14.9 | 14.1 | 0.77 | 363.3 | 703.3 | 75.5 | 78.0 | 0.42 | 8.3 |
| AAC Viewfield | 14.4 | 13.7 | 0.67 | 400.0 | 663.3 | 75.9 | 78.0 | 0.42 | 7.8 |
| **Donalda** | **15.2** | **14.3** | **0.96** | **392.0** | **499.0** | **75.2** | **78.7** | **0.41** | **7.6** |
| CV (%)[a] | 1 | 0.87 | 9.1 | 6.2 | 9 | 0.5 | 0.57 | 2.1 | 2.3 |
| LSD ($P \leq 0.05$)[b] | 0.27 | 0.22 | 0.14 | 44.3 | 101.3 | 0.63 | 0.76 | 0.02 | 0.31 |

| Cultivar | Dough properties | | | | | | Baking quality (lean no time) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Farinograph | | | Extensogram | | | | | | | |
| | Absorption (%) | Dough development time (min) | Stability (min) | Area ($cm^2$) | $R_{max}$ (BU) | Length (cm) | Absorption (%) | Mixing time (min) | Mixing energy ($W\,h\,kg^{-1}$) | Loaf volume ($cm^3\,100\,g^{-1}$) | Loaf top ratio |
| Carberry | 65.4 | 6.8 | 8.0 | 113.3 | 429.3 | 20.9 | 72.7 | 3.3 | 8.5 | 741.7 | 0.49 |
| Glenn | 66.7 | 8.2 | 10.8 | 143.3 | 642.7 | 18.5 | 74.3 | 4.1 | 10.8 | 826.7 | 0.60 |
| AAC Viewfield | 65.6 | 7.6 | 10.0 | 119.3 | 479.7 | 20.2 | 72.7 | 3.4 | 8.6 | 745.0 | 0.50 |
| **Donalda** | **65.2** | **7.2** | **9.0** | **132.3** | **479.1** | **22.0** | **72.2** | **3.4** | **9.4** | **777.6** | **0.53** |
| CV (%) | 0.44 | 11 | 9.5 | 6.7 | 8.3 | 4.7 | 0.95 | 3.3 | 8.5 | 2 | 5.8 |
| LSD ($P \leq 0.05$) | 0.53 | 1.47 | 1.67 | 16.1 | 81.9 | 1.7 | 1.71 | 0.29 | 1.96 | 38.6 | 0.08 |

**Note:** Quality data were obtained by Grain Research Laboratory of the Canadian Grain Commission using approved methods of American Association of Cereal Chemists (AACC 2000).
[a]Coefficient of variation was obtained by running a separate GLM procedure in SAS.
[b]Least significant difference = standard error of the difference between means × 1.96.

by near-infrared spectroscopy (NIRS), for Donalda (14.8%) was higher than AAC Viewfield (14.0%) but similar to Glenn (14.5%) and Carberry (14.7%) (Table 1).

## Other characteristics

### Botanical description

Donalda exhibits weak to medium coleoptile anthocyanin colouration at the seedling stage and has a glabrous lower leaf blade and sheath. At the 5–9 tiller stage, Donalda has a semi-erect plant growth habit, flag leaves with glabrous blades and sheaths, weak glaucosity on the flag leaf blade, and medium to strong glaucosity on the flag leaf sheath. Donalda has a low frequency of plants with recurved flag leaves. The flag leaf of Donalda lacks anthocyanin colouration of the auricles and has glabrous auricle margins. Donalda has a hollow, moderately curved culm neck. The culm uppermost node is glabrous and exhibits medium to strong glaucosity. Donalda has a thin straw pith and lacks anthocyanin intensity of straw at maturity. Donalda has a white stem at maturity. Donalda has parallel-sided, medium to dense awned spikes that are erect and white at maturity and exhibits medium glaucosity. The awns are present on the full length of the spike, are shorter than the spike, white at maturity, and medium spreading. The lower glume of Donalda has 43% straight, 37% slightly sloping, and 20% slightly elevated shoulders, with 80% slightly curved, 15% straight, and 1% moderately curved and long beaks. The chaff colour of Donalda is white at maturity. The kernels of Donalda are hard, medium red, small to medium in size and length, narrow to medium in width, broad-elliptical, with rounded cheeks. It has a small kernel brush with short brush hairs. The kernel crease is narrow to mid-wide and shallow to mid-deep. Donalda has a mid-size and rounded germ.

### Disease resistance

Donalda was rated resistant (R) to the prevalent races of stem rust at Morden and Brandon and moderately resistant (MR) to R to leaf rust and stripe rust during the 3 years of testing (Table 2). Its reaction to common bunt was intermediate (I) in 2017 in the Parkland B test (data not given), moderately susceptible (MS) in 2018, and MR in 2019 (Table 2). Based on the visual rating index of FHB, Donalda was rated MR in Carman during the 3 years of testing, whereas MR in 2018, I in 2019, and MR in 2020 at Morden (Table 3). Based on deoxynivalenol (DON) values, Donalda was rated MR in 2018 and 2020 and I in 2019 at Morden, MB, whereas I in 2018 and 2019 and MR in 2020 at Carman, MB (Table 3). The disease evaluation team of the PRCWRT gave Donalda a final rating of R for leaf, stem, and stripe rusts, MS for the common bunt, and I for FHB.

### End-use quality

Three years of end-use quality evaluation has indicated that Donalda is acceptable for the CWRS market class, with improved grain and flour protein and excellent EXT Length (Table 4). The grain and flour protein of Donalda was similar to Carberry and Glenn but lower than AAC Viewfield (Table 4). Protein loss on milling was similar to Carberry but significantly higher ($P < 0.05$) than AAC Viewfield and Glenn. The falling number of Donalda was similar to the checks. Amylograph peak viscosity was similar to Carberry but lower than AAC Viewfield and Glenn. Clean flour yield of Donalda was similar to Glenn but lower than AAC Viewfield and Carberry, whereas flour yield on a 0.5 ash basis was similar to the checks. Starch damage was similar to AAC Viewfield and Carberry but lower than Glenn. Farinograph absorption was lower than Glenn but similar to the other checks, whereas dough development time was in the range of checks. Farinograph stability of Donalda was lower than Glenn but similar to the other checks. The extensogram area was higher than Carberry but similar to other checks. The $R_{max}$ value of Donalda was similar to AAC Viewfield and Carberry but lower than Glenn. Lean no time absorption and mixing time was similar to AAC Viewfield and Carberry but lower than Glenn. Mixing energy was similar to the checks (Table 4). The loaf volume of Donalda was lower than Glenn but similar to other checks. Loaf top ratio was lower than Glenn but higher than the other checks.

### Maintenance and distribution of pedigreed seed

The breeder seed of Donalda derives from the 2017 Parkland B trial. The source seed was grown in 2018 in Edmonton, AB, and 150 heads were picked. The 150 heads were grown in 1 m pre-breeder rows in 2019 in Edmonton, of which 119 uniform rows were individually harvested. Seeds of 119 rows were planted in 15 m breeder rows in 2020 at Edmonton, and 107 uniform rows were harvested in bulk to produce approximately 250 kg of breeder seed. The breeder seed of Donalda will be maintained by the University of Alberta's Cereal Breeding Program, Edmonton, AB. Multiplication and distribution of other classes of pedigreed seed will be handled by Lyster Farms Ltd., Stettler, Alberta.

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### Data availability

Data used in this manuscript are available on PRCWRT website to committee members at PRCWRT Committee Page (pgdc.ca).

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### Competing interests

The authors declare no competing interests.

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