### AAC Cranford cranberry dry bean

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CULTIVAR DESCRIPTION

AAC Cranford cranberry dry bean

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Abstract: AAC Cranford is an early maturing cranberry dry bean (*Phaseolus vulgaris* L.) cultivar with high yield, an upright determinate bush (Type I) growth habit and large seed size. Currently, dry bean cultivars in the cranberry bean market class are only commercially grown in Manitoba and Ontario primarily due to their late maturity. Therefore, AAC Cranford with its early maturity and high yield potential will enable growers to commercially produce cranberry bean in Alberta and Saskatchewan.

Key words: AAC Cranford, high yield, early maturity, large seed size, cranberry bean

Introduction

Cranberry bean is a large-seeded (100-seed weight > 45 g) dry bean market class similar to dark red, light red and white kidney bean market classes for seed weight. Cranberry bean cultivars are grown on approximately 8,100 ha each year in Canada primarily in Ontario (J. Mitchell, Ontario Bean Growers, Pers. Commun.) and Manitoba (Manitoba Agricultural Services Corporation 2017). However, they are not grown in Alberta and Saskatchewan due to the late maturity (over 100 days) of the cultivars currently registered in Canada. Although cranberry bean market class hectares are relatively small compared to navy and pinto bean market classes, each of which are grown on over 35,000 ha in Canada, early maturing cranberry bean cultivars may enable growers, especially those in AB and SK to diversify their dry bean production. Therefore, AAC Cranford, an early maturing, high yielding cranberry bean cultivar with a large seed size was developed by Agriculture and Agri-Food Canada (AAFC), Lethbridge Research and Development Centre, Lethbridge, AB. It was tested as F07-179 in early generation nurseries (F$_2$ to F$_5$), and as L12CB004 in yield trials starting in the F$_6$ generation. L12CB004 was grown in the
Short Season Wide Row Irrigated Dry Bean Cooperative Registration Trial in Alberta and Saskatchewan from 2014 to 2016, and was registered as AAC Cranford on 29 June 2018 (Registration no. 8580), by the Variety Registration Office, Canadian Food Inspection Agency, Ottawa, ON.

**Pedigree and Breeding Method**

AAC Cranford was derived from the cross Cran 09/W06-043 made at the AAFC Lethbridge Research and Development Centre in 2007. Cran 09 (PI 561213) is a cranberry bean cultivar developed by Gen-Tec Seeds, Ltd., Twin Falls, ID, USA, and was used as a parent for its large seed size and low incidence of marsh spot, a physiogenic disorder characterised by discolouration of the inner flat surface of the cotyledon (Glasscock and Wain 1940; Moraghan and Grafton 2000). W06-043 was a F₁ hybrid of the cross Etna/Hooter made in 2006. Etna (PI 546490) is a cranberry bean cultivar developed by Seminis Vegetable Seeds (now Bayer), and was used as a parent for its early maturity when grown in yield trials in Manitoba. Hooter, also a cranberry bean cultivar developed by Seminis Vegetable Seeds, was used as a parent for its large seed size.

AAC Cranford was developed by a modified pedigree breeding method. Ten F₁ plants of the cross were grown in a greenhouse at Lethbridge in 2008, and the F₂ seeds from each plant were harvested and sent to the winter nursery in Chile in fall 2008. The F₃ seeds were bulk harvested in Chile, and were planted in 12 rows and 8 rows, respectively in the F₃ nurseries grown at Lethbridge and Vauxhall, AB in 2009. Single-plant selections were made based on upright determinate bush (Type I) growth habit (Brick and Johnson, 2004), early maturity, yield potential (number and distribution of pods on the plant) and cranberry bean seed traits (size, shape and
colour pattern). In total, 25 plants were selected from the F3 nurseries grown at both locations. The selections were advanced to F4 nurseries that were grown at Lethbridge and Vauxhall in 2010, but single-plant selections were made only at Vauxhall. The F4 nursery in Lethbridge was lost due to waterlogging. A plant was selected in Vauxhall from the F4 nursery.

Progeny-row yield was added to the selection criteria in the F5 yield trial, which was conducted in 2011 as a Modified Augmented Design (MAD type 2) (Lin and Poushinsky 1985). The one cranberry bean line selected from the F4 nursery in Vauxhall was tested in the F5 yield trial grown at Lethbridge. The row length of the single-row plots was 5 m with 60 cm spacing between rows. A selection, VF07-179-8-0-21-1 from the F5 yield trial was tested as L12CB004 in the wide row (60 cm row spacing) Preliminary (F6) Yield Trial at Fairfield Research Farm (near Lethbridge) in 2012. A Modified Augmented Design was used instead of a replicated yield trial due to insufficient seed, and the plot consisted of two-rows. L12CB004 was grown in the Advanced (F7) Yield Trial with three replications at Fairfield Research Farm and two replications at Vauxhall in 2013. Based on seed yield and quality, lodging resistance, early maturity, and upright determinate bush growth habit, L12CB004 was advanced to the Short Season Wide Row Irrigated Dry Bean Cooperative Registration Yield Trial from 2014 to 2016. The Cooperative Registration Yield Trial was grown at four locations (Fairfield Research Farm, Vauxhall and Bow Island, AB and Outlook, SK) in 2014 and 2015, and five locations (Fairfield Research Farm, Vauxhall, Bow Island, Cranford and Lethbridge) in 2016 with four replications per location. The Cooperative Registration Yield Trial at Vauxhall was lost due to hail in early-June in 2015, and waterlogging in 2016. Also, seed yield data from the Cooperative Registration Yield Trial at Vauxhall and Fairfield Research Farm in 2014 were not included in the statistical analysis due to a high CV (> 20%). In the Advanced and Cooperative Registration Yield Trials,
plots consisted of four rows with a row length of 5 m, and the experimental design was a lattice. Red Rider (Park et al. 2009), a cranberry bean cultivar developed by AAFC-Harrow, ON was included as the check cultivar in the Cooperative Registration Trial. Red Rider is a late maturing cultivar when grown in Alberta, however, it was used as a check cultivar as disease-free seed from Idaho, USA was readily available compared to Etna, the predominant cranberry bean cultivar grown in Ontario and Manitoba.

Performance

Agronomic traits

In the Short Season Wide Row Irrigated Dry Bean Cooperative Registration Yield Trial grown at nine station-years between 2014 and 2016, AAC Cranford (experimental line L12CB004) averaged 3.27 t ha\(^{-1}\), which was 39% higher yielding than the check cultivar Red Rider (Table 1). AAC Cranford matured four days earlier compared to the check cultivar Red Rider (Table 1). The average seed weight of AAC Cranford over the 11 station-years was 18% greater than Red Rider. At maturity, AAC Cranford had slightly poorer lodging resistance compared to Red Rider (1.7 vs. 1.4) on a scale of 1 = upright plants to 5 = plants with weak stem and prostrate growth (Table 1). The difference in lodging between the two cultivars was small, but statistically significant. Plant growth habit and flower colour were assessed at flowering. AAC Cranford has a determinate bush (Type I) growth habit (Brick and Johnson, 2004), similar to Red Rider. AAC Cranford has a pink standard and wing petals, similar to Red Rider.

Disease Resistance
AAC Cranford was assessed for partial field resistance (i.e., avoidance) to white mould, caused by *Sclerotinia sclerotiorum* (Lib.) de Bary, in an inoculated and irrigated disease nursery at AAFC-Lethbridge from 2014 to 2016 (Balasubramanian et al. 2014). White mould incidence and severity of AAC Cranford were slightly higher than that of the check cultivar Red Rider (Table 1). Seedling resistance to race 73 and 105 of *Colletotrichum lindemuthianum* (Sacc. & Magnus) Briosi & Cav., the causal agent of anthracnose was assessed in a greenhouse at AAFC-Morden (Balardin et al. 1997; Dongfang et al. 2008). AAC Cranford was susceptible to both races of anthracnose (data not shown), whereas Red Rider was resistant to race 73. Based on visual observations in the field in southern Alberta, under natural inoculation conditions, both AAC Cranford and Red Rider were susceptible to common bacterial blight, caused by *Xanthomonas axonopodis pv. phaseoli* (Smith) Vauterin et al. (Vauterin et al. 1995); syn. *X. campestris pv. phaseoli* (E.F. Smith) Dye.

**Seed quality**

Consumer preferences for dry bean seed quality vary by market class and end-use. Cranberry bean seeds are sold as both dry seed based on visual seed quality traits including seed size, shape, and colour, and after processing in cans. Seeds of AAC Cranford and Red Rider cranberry bean harvested from individual research plots (i.e., four replications) of the Cooperative Registration Yield Trial grown at four locations in 2016 (i.e., Bow Island, Cranford, Fairfield Research Farm, and Lethbridge) were subjected to cooking and canning quality assessments in the Bean Pilot Plant at AAFC-Lethbridge. In addition to the 100-seed weight which was determined as part of the agronomic traits (Table 1), the dry seed was assessed for L* (light-dark, with higher values for lightness), a* (red-green, with positive value for redness and negative
values for greenness), and b* (yellow-blue, with positive value for yellowness and negative values for blueness) attributes of colour using a CR-410 Chromameter (Konica Minolta Sensing Americas, Inc., Ramsey, NJ, USA). Dry seed colour attributes of AAC Cranford and Red Rider were similar (L* = 53.3 vs. 54.2; a* = 7.8 for both, and b* = 11.8 vs. 11.5).

For the cooking quality, 200 seeds per replication per location were soaked in deionised water at room temperature (21°C) for 16 h and cooked for 20 min at 95°C. The percentage of hard seed and partially hydrated seed were determined before cooking (i.e., after soaking) and after cooking. The hydration coefficients before and after cooking were determined as seed weight before cooking or after cooking / weight of dry seed. Percentage hard seed before cooking in AAC Cranford and Red Rider was similar (0.15% vs. 0.18%). After cooking, hard seeds were not detected in the seed samples of either cultivars. The percentage of partially hydrated seed before cooking was also similar between the two cultivars (9.7% for AAC Cranford vs. 6.4% for Red Rider), however, the percentage of partially hydrated seed after cooking was reduced to 1.1% for AAC Cranford and 0.2% for Red Rider, which was different between the cultivars. The hydration coefficients before and after cooking were similar for both cultivars at 2.1 and 2.5, respectively.

For the canning quality assessment, moisture content of seed was determined using a GAC2500-INTL Moisture Tester (Dickey-john, Auburn, IL), and 86 g of seed on a moisture-free basis were soaked in deionised water at room temperature (21°C) for 16 h and blanched for 3 min at 93°C in deionised water. The hydration coefficients were determined after soaking and blanching as seed weight after soaking or blanching / weight of dry seed. Blanched seeds were transferred to 398 ml cans and filled with a 1% (w/v) salt solution prepared using deionised water. Cans were processed at 121°C for 20 min at 4 rpm using a 2402 Multimode R&D Retort.
(Allpax Products, LLC, Covington, LA, USA), and cooled in cold running water for 20 min at 4 rpm. Cans were stored for two weeks prior to opening for assessment. Matting (clumping) of seeds was assessed on a 1 to 4 scale, where 1 = none, 2 = trace, 3 = slight, and 4 = moderate. Seeds were assessed for their appearance (broken and split seed, and free seed coat) using a 1 to 4 scale, where 1 = excellent, 2 = good, 3 = acceptable, and 4 = poor. The can content was weighed, and the drained weight of bean seed was determined after washing in tap water on an 8-mesh screen (Tyler series) positioned at a 15° angle. Percentage drained weight was determined as (weight of bean seed / weight of can contents) *100. The texture (kg force) was determined by placing 100 g of washed drained bean in to a standard shear compression cell (CS-1) of Texture Measurement System - Touch (TMS-Touch, Food Technology Corp., Sterling, VA, USA) and shearing them using a load cell of 255 kg-force at a rate of 0.83 cm sec\(^{-1}\). The colour of processed (canned) seed was assessed using a CR-410 Chromameter.

Hydration coefficient after soaking was similar (2.1) for both cultivars, however, the hydration coefficient after blanching of AAC Cranford was slightly higher compared to Red Rider (Table 2). A hydration coefficient of 2.0 or higher is generally preferred by processors as it reduces the amount of bean seeds required to fill a can. Drained weight of AAC Cranford was 2% higher than that of Red Rider, but both were > 60% indicating more than 60% of the can content was cranberry bean seed. Seeds of both AAC Cranford and Red Rider showed no matting, and the appearance after canning was good, indicating whole seeds remained intact with very few split seeds and/or free seed coats. The texture or firmness of AAC Cranford was also 7% higher than Red Rider (Table 2). After canning, seed coat colour attributes of AAC Cranford and Red Rider were similar (L* = 33.8 vs. 34.3; a* = 12.6 vs. 12.2, and b* = 15.4 vs. 15.7).
Development, Maintenance and Distribution of Pedigreed Seed

The breeder seed production of AAC Cranford was started in 2014. Two hundred pods were randomly selected from plants grown in a seed increase nursery at Vauxhall. The pods were hand-threshed individually and seeds (F$_9$) with the size, shape and colour appropriate for a cranberry bean were selected. The seeds were grown in the greenhouse at Lethbridge in the winter of 2015 and the plants were harvested individually. After examining the seed (F$_{10}$), 54 progeny-rows were planted at Twin Falls, Idaho in the summer of 2015. The seeds from the 54 progeny-rows were bulked and this F$_{11}$ seed formed the first breeder seed. Breeder seed of AAC Cranford will be maintained by the AAFC Lethbridge Research and Development Centre, Lethbridge, AB. AAC Cranford was released on an exclusive basis for seed production and marketing to Viterra Inc., 2802 -5$^{th}$ Avenue North, Lethbridge, AB, T1H 0P1, where pedigreed seed may be purchased.

Acknowledgements

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References


Table 1. Means of agronomic and disease traits of the cranberry bean cultivar AAC Cranford and the check cultivar Red Rider grown in Alberta and Saskatchewan from 2014 to 2016.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Yield (t ha(^{-1}))</th>
<th>Maturity (days)</th>
<th>Seed weight (g 100 seeds(^{-1}))</th>
<th>Lodging resistance(^a)</th>
<th>White mould(^b) Incidence (%)</th>
<th>Severity (1–4)</th>
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<tr>
<td>AAC Cranford</td>
<td>3.27</td>
<td>100</td>
<td>62.3</td>
<td>1.7</td>
<td>24</td>
<td>1.5</td>
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<tr>
<td>Red Rider</td>
<td>1.99</td>
<td>104</td>
<td>51.1</td>
<td>1.4</td>
<td>17</td>
<td>1.3</td>
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<td>LSD(_{0.05})</td>
<td>0.26</td>
<td>1</td>
<td>1.3</td>
<td>0.2</td>
<td>6</td>
<td>0.2</td>
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<tr>
<td>(P)</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.10</td>
<td>0.03</td>
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<td>Station–years</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>3</td>
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**Note:** LSD, least significant difference and \(P\) value. LSD was calculated from a pooled error term of all entries common to the Short Season Wide Row Irrigated Dry Bean Cooperative Registration Trial from 2014 to 2016. Data were from four replications of trials grown at Bow Island (2014-2016), Cranford (2016), Fairfield Research Farm (2015-2016), Lethbridge (2016) and Outlook (2014-2015).

\(^a\)Lodging resistance was determined at maturity using a 1 to 5 scale, from 1 = upright plants, 3 = partially upright plants, to 5 = plants lodged due to weak stem.

\(^b\)White mould incidence refers to the mean percentage of plants with symptoms in the inoculated disease nursery at Lethbridge from 2014 to 2016. White mould severity was assessed using a 1 to 4 scale, where 1 = healthy plants, 2 = plants have one infected branch or pod, 3 = plants have multiple infected branches or pods, and 4 = main stem is girdled or plants were dead.
Table 2. Means of canning quality traits of the cranberry bean cultivar AAC Cranford and the check cultivar Red Rider grown at four locations in Alberta in 2016.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>HCS</th>
<th>HCB</th>
<th>Drain weight (%)</th>
<th>Matting (1–4)</th>
<th>Appearance (1–4)</th>
<th>Texture (kg force)</th>
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<tr>
<td>AAC Cranford</td>
<td>2.1</td>
<td>2.4</td>
<td>63.0</td>
<td>1.2</td>
<td>2.2</td>
<td>34.4</td>
</tr>
<tr>
<td>Red Rider</td>
<td>2.1</td>
<td>2.3</td>
<td>61.6</td>
<td>1.2</td>
<td>2.2</td>
<td>32.1</td>
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<tr>
<td>LSD_{0.05}</td>
<td>0.03</td>
<td>0.03</td>
<td>0.7</td>
<td>0.3</td>
<td>0.2</td>
<td>2.1</td>
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<tr>
<td><em>P</em></td>
<td>0.07</td>
<td>&lt;0.01</td>
<td>0.01</td>
<td>0.72</td>
<td>0.97</td>
<td>0.06</td>
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**Note:** LSD, least significant difference and *P* value. Data were from seeds harvested from four replications of the Short Season Wide Row Irrigated Dry Bean Cooperative Registration Trial grown in 2016 at Bow Island, Cranford, Fairfield Research Farm and Lethbridge.

*a* Hydration coefficient after soaking (HCS): 86 g of cranberry bean seed was soaked for 16 h in deionised water at room temperature (21°C). Hydration coefficient after soaking was determined as: seed weight after soaking / weight of dry seed.

*b* Hydration coefficient after blanching (HCB): Soaked seed was blanched for 3 min at 93°C. Hydration coefficient after blanching was determined as: seed weight after blanching / weight of dry seed.

*c* Drain weight (%): Bean seeds were processed at 121°C for 20 min in brine using a 2402 Multimode R&D Retort (Allpax Products, LLC, Covington, LA). Can content was weighed and the weight of bean seed was determined after washing in tap water on a 8-mesh screen (Tyler series) positioned at a 15° angle. Percentage drain weight was determined as: (weight of bean seed / weight of can contents) * 100.

*d* Matting (clumping) of seeds was assessed on a 1 to 4 scale, where 1 = none, 2 = trace, 3 = slight and 4 = moderate.

*e* Appearance of seeds was assessed on a 1 to 4 scale, where 1 = excellent, 2 = good, 3 = acceptable, and 4 = poor.

*f* Texture (Firmness) (kg force 100 g seed^{-1}) was determined by placing 100 g of washed drained bean in to a standard shear compression cell (CS-1) of Texture Measurement System - Touch (TMS-Touch, Food Technology Corp., Sterling, VA) and shearing them using a load cell of 255 kg force at a rate of 0.83 cm sec^{-1}. 

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