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AAC Justice oat

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Abstract

AAC Justice is a white-hulled spring oat (*Avena sativa* L.) cultivar. It was postulated to carry the crown rust resistance gene *Pc91*, which was effective against the prevalent crown rust races on the Canadian Prairies at the time of its release. It had very good resistance to loose and covered smut and moderate resistance to most of the prairie stem rust races, and was intermediate in reaction to the barley yellow dwarf virus. AAC Justice has a high test weight, average kernel weight, and average groat percentage and kernel plumpness. AAC Justice exhibited high yield potential in the eastern oat-growing areas of Western Canada. AAC Justice was registered (reg. no. 7439) in Canada on 15 October 2013.

Key words: oat, *Avena sativa* L., cultivar description, milling oat, crown rust resistance, oat stem rust resistance

Résumé

AAC Justice est une variété d'avoine de printemps (*Avena sativa* L.) à balle blanche qu'on suppose porter le gène *Pc91* de résistance à la rouille couronnée. À son homologation, le cultivar avait affiché une bonne résistance contre les principales races de l'agent pathogène, dans les Prairies canadiennes. AAC Justice résiste très bien au charbon nu et au charbon couvert, résiste modérément à la majorité des races de rouille de la tige qui sévissent dans les Prairies et réagit de façon intermédiaire au virus de la jaunisse naissante de l'orge (VJNO). La variété se caractérise par un poids spécifique élevé, un grain de poids moyen ainsi qu'une proportion moyenne de gruaux et un grain moyennement ventru. AAC Justice enregistre un rendement potentiel élevé dans les régions est de l'Ouest canadien où l'on cultive l'avoine. La variété a été homologuée (numéro d'enregistrement 7439) au Canada le 15 octobre 2013. [Traduit par la Rédaction]

Mots-clés : avoine, *Avena sativa* L., description de cultivar, avoine de mouture, résistance à la rouille couronnée, résistance à la rouille de la tige

Introduction

AAC Justice is a white-hulled, multiple-disease-resistant oat (*Avena sativa* L.) cultivar developed jointly by Agriculture and Agri-Food Canada, Cereal Research Centre (AAFC-CRC), Winnipeg, MB, Canada, and the University of Minnesota, St. Paul, MN, USA. AAC Justice was supported for registration at a Prairie Grain Development Committee (PGDC) meeting in February 2013. It was registered (reg. no. 7438) by the Variety Registration Office, Canadian Food Inspection Agency, on 15 October 2013. AAC Justice exhibits good yield potential in the oat-producing areas of Western Canada. AAC Justice was named, first, to honor the breeder orchestrating the original cross, Dr. Deon Stuthman, who served the Department of Agronomy and Plant Genetics at the University

of Minnesota, St. Paul, MN, for over 42 years. Dr. Stuthman died on 18 June 2010. Dr. Stuthman worked hard to ensure that everyone enjoyed fairness and justice, and helped create the Vincent L. Hawkinson Foundation for Peace & Justice (<http://hawkinsonfoundation.org/>). AAC Justice is also named after a small community located in the rural municipality of Elton, northeast of Brandon, MB. The Justice School was in operation until June 1967, and Justice hosted a wooden grain elevator until 2018.

Pedigree and breeding method

AAC Justice is a white-hulled F₅-derived oat cultivar from the cross ND020965/SA050100 utilizing a modified pedigree

Table 1. Grain yield (kg ha⁻¹) of AAC Justice (OT2084) and check cultivars in the WCORT 2011–2012 in Western Canada by soil zones.

Cultivar	Soil zone				Mean
	Black ^a	Black and Grey ^b	Brown ^c	Brown and Dark Brown (irrigated) ^d	
CDC Dancer	4184	5963	5330	6443	5111
AC Morgan	4678	7110	5803	7501	5813
Leggett	4749	5888	5923	6359	5463
AAC Justice	5104	6570	6256	6579	5891
LSD ^e (<i>P</i> = 0.05)	351.4*	402.3*	524.4*	695.4*	239.9*
Station-years	11	7	7	2	27

^aTests grown near Brandon (2012), Morden (2011, 2012), Portage la Prairie (2011, 2012), Indian Head (2011, 2012), Glenlea (2011, 2012), and Oakbank (2012), MB, and Melfort, SK (2012).

^bTests grown at Beaverlodge (2011, 2012), Fort Vermilion (2011), and Lacombe (2011, 2012), AB, and Dawson Creek, BC (2011, 2012).

^cTests grown near Kernen (2011, 2012), Regina (2011), Swift Current (2011, 2012), and Watrous (2011, 2012), SK.

^dTest grown under irrigation near Lethbridge, AB (2011, 2012).

^eMean separation and Least Significant Difference (LSD) were calculated utilizing the SAS PROC Mixed macro (Saxton 1998).

method. ND020965 is a breeding line with high beta-glucan concentration and resistance to oat crown rust (*Puccinia coronata* Cda f. sp. *avenae* Eriks.) and oat stem rust (*Puccinia graminis* Pers. F. Sp *avenae* Eriks. and E. Henn.), developed at North Dakota State University from the cross ND960620/HiFi (HiFi, McMullen et al. 2005). ND960620 resulted from a cross between ND900118 and Marion. ND900118 descended from the cross between two breeding lines, ND852158 (from the cross Hudson/Lang//Dal/3/Dx7/M51) and MN78142 (from the cross Otter/3/Garland/Clav 8081//MN860/Avon). ND900118 was used in other crosses that produced successful cultivars such as Drover, HiFi, and Souris.

SA050100 is a breeding line developed from the cross Furlong/OT384 (Furlong, Mitchell Fetch et al. 2006) at the Crop Development Centre, University of Saskatchewan. The cross that produced AAC Justice was made at the University of Minnesota during the fall of 2005. The F₁ generation was grown in the 2006 spring greenhouse at the University of Minnesota. The F₂ generation was grown in a space-planted nursery at the University of Minnesota during the summer of 2006, with approximately 50 seeds from each cross planted in a 40-foot-long (~12 m) row. Individual plants were discarded for poor disease reactions, mostly to oat crown rust (OCR), and poor agronomic performance, such as very tall, lodged, and later maturing plants. Dr. Deon Stuthman, anticipating his retirement, asked Dr. Jennifer Mitchell Fetch to select desirable lines from his breeding program material in New Zealand for testing within the AAFC program in Winnipeg, MB. Seed from 28 individual panicles, selected in February 2007 from F₃ hill plots planted near Palmerston North, New Zealand, was grown as F₄ hill plots in the summer of 2007 at AAFC-CRC, in Winnipeg, MB. These plots were artificially inoculated with loose smut (*Ustilago avenae* (Pers.) Rostr.), OCR, and oat stem rust (OSR), using a mixture of predominant races collected in previous years. Seed from 18 disease-resistant progeny lines was planted in hill plots at the 2007–2008 winter nursery located near Palmerston North, New Zealand. In the winter nursery, 10 panicles were selected from each of 12 F₅ hills based on resistance to oat crown

rust, tolerance to barley yellow dwarf virus (BYDV), and plant appearance. The best five panicles were selected from each hill based on visually distinguished kernel plumpness, hull colour, and absence of awns. Seed from 60 selected panicles was planted as panicle hill plots in the F₆ rust/smud nursery near Winnipeg, MB, in 2008. These plots were artificially inoculated with loose smut, oat crown rust, and oat stem rust. Twenty-two agronomically desirable (acceptable height, maturity, and lodging resistance) disease-resistant hill plots were selected, and seed from each of these hills was grown as F₇ hill plots in the 2008–2009 winter nursery in New Zealand. The New Zealand F₇ winter nursery consisted of two replicates (rep) of each breeding line with two adjacent hills per rep, for a total of four hills per line. Concurrently, the selected F₇ lines were screened for quality characteristics using near-infrared reflectance spectrophotometry and for oat crown and oat stem seedling rust resistance using known tester races in the greenhouse at Winnipeg. Bulk-harvested seed from the four hills of each of three lines selected for quality and disease reactions provided F₈ seed for the 2009 Preliminary Yield Trial, grown in single replicates at Winnipeg, Portage la Prairie, and Brandon, MB, and Lacombe, AB. These lines were then tested for 1 year in the 2010 Rust Area Test (RAT) grown in three replicates at nine sites across Manitoba, Saskatchewan, and Alberta, and in disease nurseries in Manitoba. Two of these lines were selected for superior overall performance and tested in the Western Cooperative Oat Registration Test (WCORT) in 2011 for comparative agronomic, disease, and quality characteristics. One of these lines, tested as 06Mn25-AP1 and OT2084, was advanced to the 2012 WCORT, where it continued to exhibit good overall performance. OT2084 was registered as AAC Justice after gaining support at the February 2013 PGDC meeting. Two hundred twenty panicles selected from a rogued F₉ increase plot grown near Lacombe, AB, in 2010 were grown in plots of paired 1 m rows in isolation near Glenlea, MB, in 2011 and selected for uniformity to provide seed for 15-m-long rows produced at Indian Head, SK, in 2012. Of these, 215 rows were selected based on their continued uniformity, and the

Table 2. Summary of agronomic and quality data for AAC Justice (OT2084) and check cultivars in the WCORT in Western Canada 2011–2012.

Cultivar	Days to head	Days to mature	Height (cm)	Lodging resistance ^a (1–9)	Test weight (kg hL ⁻¹)	Kernel weight (mg)	Groat (%) ^b	Plump (%) ^c	Thin (%) ^d	TDF analytical (%) ^e	β -Glucan analytical (%) ^e	Protein (%) ^f	Oil (%) ^g
CDC Dancer	59	92	103	2.4	54.4	34.5	73.6	84.6	5.3	9.6	4.3	14.5	6.7
AC Morgan	59	95	101	2.1	51.2	35.1	66.8	74.9	6.4	9.9	4.4	14.4	6.6
Leggett	57	95	96	2.1	54.4	35.3	70.7	80.1	5.5	10.0	5.1	16.6	7.7
AAC Justice	60	95	102	2.5	55.0	34.5	70.2	74.2	7.0	10.7	5.2	14.6	7.8
LSD ^h ($P = 0.05$)	0.5*	0.8*	1.62*	0.5, ns	1.4*	1.4, ns	2.4*	9.7*	4.0, ns	0.7*	0.2*	0.6*	0.4*
Significance ⁱ	*	*	*	ns	*	ns	*	*	ns	*	*	*	*
Station years	13	23	23	13	25	25	12	12	12	6	12	12	12

^a1 = no lodging; 9 = completely lodged.

^bGroat percentage determined on a 50 g sample using a Codema dehuller.

^cPercentage of plump kernels based on proportion of a 50 g sample remaining on top of a 2.18 mm \times 19.05 mm (5 $\frac{1}{2}$ /64 $\frac{3}{4}$ in.) sieve.

^dPercentage of thin kernels based on proportion of a 50 g sample passing through a 1.98 mm \times 19.05 mm (5/64 $\frac{3}{4}$ in.) sieve.

^eStandard analytical procedures were used to determine β -glucan (AACC32-23) and TDF (AACC3207).

^f2011 data supplied by N. Ames, AAFC-Winnipeg. Standard LECO procedures were used to quantify protein. 2012 data supplied by N. Ames, AAFC-RCFN. Wholemeal samples were scanned and predicted using the near-infrared reflectance spectrophotometer Unity Spectra Star 2400. Samples were dehulled and groats were ground into wholemeal (Retsch centrifugal mill, 0.5 mm screen) prior to scanning.

^gWholemeal samples were scanned and predicted using the near-infrared reflectance spectrophotometer Unity Spectra Star 2400.

^hMean separation and LSD were calculated utilizing the SAS PROC Mixed macro (Saxton 1998).

ⁱSignificance at $P = 0.05$ indicated as “ns” (not significant) or “*” (significant).

Table 3. Summary of disease reactions for AAC Justice (OT2084) and check cultivars in the WCORT 2011–2012.

Cultivar	Field ratings			Seedling reaction to selected races of oat crown rust ^e									Seedling reaction to selected races of oat stem rust ^f					
	BYDV ^a (1–9)	Loose Smut ^b %	OCR ^c	OSR ^d	CR13 SJQL-96	CR223 NGCB-94	CR241 DSGB	CR249 DQBG-94	CR254 LRBG	CR257 BRBG-94	CR258 NTGG	CR259 LQCB-91	NA8 FDJ	NA25 NA16NGBIDD	NA27 TGB	NA28 TGL	NA67 TJJ	
2011 Western Coop																		
CDC Dancer	7.8 S	0	TR	5 i	0	0	4	4	4	4	4	;1(4)	;1–	11+	1–	;1	11+	33+
AC Morgan	7.3 S	16	2 MS	50 mss	4	4	4	4	4	4	4	4	3–3	33+	3–	33+	3–	33+
Leggett	8.1 S	0	R	3 i	0	0	0	0	0	4	0	0	;1	;1	2+	;1	1–	33+
AAC Justice	5.6 MS	0	R	5 i	0	0	0	0	0	;–	;f	4	;1–	;1–	1	;1	;1–	11+
2012 Western Coop																		
CDC Dancer	6.9 S	0	tr S	25 i	0	0	4	4	0	4	4	;(4)	0;	1–	1–	1–1	12–	33+
AC Morgan	6.6 S	15	2 S	70 s	4	4	4	4f	4	4	4	4	3+	33+	4	34	4	33+
Leggett	6.8 S	0	R	50 ms	0	0	0	0	0	4	0	0	;1–	;1–	1–	1	11+	33+
AAC Justice	5.4 I	0	R	40 i	0	0	;–	0	;1–	;–	;–	4	0;	;1–	;1–	;1–	1	4(1) 1(3+)

^aVirulent *Rhizoglyphus padi* nonspecific isolate Y9301 (PAV-like) was used. BYDV readings were taken at mid-dough using a 1–9 (best–worst) scale; R = 1–3.5, MR = 3.51–4.5, MR–MS or I = 4.51–5.5, MS = 5.51–6.5, and S = 6.51–9.0.

^bSmut data: a mixture of three races of Black Loose Smut (*U. avenae* (Pers.) Rostr.), A13, A60, and A617, was used as inoculum. %Infection, R = 0%–15%, MR = 16%–35%, MR–MS = 36%–55%, MS = 56%–75%, and S > 75%.

^cOat crown rust: field ratings based on artificial inoculation with composite of isolates bulked from the previous year annual crown rust survey in Manitoba. Ratings follow Peterson et al. (1948), where 0 = immune; VR = very resistant; Tr = trace; R = resistant; MR = moderately resistant; MS = moderately susceptible; and S = susceptible.

^dOat stem rust: field ratings based on reaction to an artificially inoculated mixture of races (NA8, 16, 25, 27, 28, 55, and 67). Ratings follow Peterson et al. (1948) as listed above.

^eOCR greenhouse ratings: all entries were inoculated with selected races of crown rust in greenhouse seedling tests. Ratings follow Stakman et al. (1962).

^fOSR greenhouse ratings: all entries were inoculated with seven selected races of stem rust in greenhouse seedling tests. Ratings follow Stakman et al. (1962).

seed produced was bulked to form the breeder seed for AAC Justice.

Performance

Based on agronomic, kernel quality, and disease data, AAC Justice is suited for all oat-growing areas of Western Canada. Over all environments, AAC Justice produced significantly more grain than CDC Dancer and Leggett, and the grain yield was similar to that of AC Morgan, which was the high-yielding check in the WCORT. In the Eastern Prairies (Black Soil Zone), where crown rust often reduces yield, AAC Justice produced significantly more grain than AC Morgan, CDC Dancer, and Leggett (Table 1). AAC Justice yielded more than the checks in the Brown Soil Zone, but produced less grain than AC Morgan in the Black and Grey, and irrigated Brown soil zones of Western Canada (Table 1).

AAC Justice headed significantly later (more than 1 day) than all the check cultivars (Table 2). AAC Justice matured, on average, almost 3 days later than CDC Dancer, less than half a day later than Leggett, and similarly to AC Morgan. AAC Justice was intermediate in height to AC Morgan and CDC Dancer and significantly taller than Leggett. The lodging resistance of AAC Justice was similar to the check cultivars. AAC Justice was significantly higher in test weight than AC Morgan but similar to CDC Dancer and Leggett, and had lower kernel weight than AC Morgan and Leggett. The groat percentage of AAC Justice was significantly greater than that of AC Morgan but significantly lower than that of CDC Dancer. The percentage of plump kernels was substantially lower than that of CDC Dancer and similar to those of the other check cultivars. The percentage of thin kernels, however, was similar to those of all the check cultivars. The total dietary fibre (TDF) content was higher than those of all the check cultivars and significantly higher than those of CDC Dancer and AC Morgan. The β -glucan content of AAC Justice was significantly higher than those of CDC Dancer and AC Morgan, and similar to that of Leggett. The protein content in AAC Justice was significantly lower than that of Leggett, but similar to those of CDC Dancer and AC Morgan. The oil content of AAC Justice was similar to that of Leggett, and was significantly higher than those of CDC Dancer and AC Morgan (Table 2). Mean separation and Least Significant Difference (LSD) were calculated utilizing the SAS PROC Mixed macro (Saxton 1998).

Disease reaction

AAC Justice is resistant to loose smut and covered smut and is more tolerant than the check cultivars to BYDV (Table 3). AAC Justice exhibits good resistance to oat crown rust and showed intermediate resistant field reactions to oat stem rust (Table 3). AAC Justice likely carries *Pc91*, based on its parentage and seedling reaction to individual oat crown rust races. AAC Justice has resistance to the virulent TJJ (North American Rust Race Nomenclature) race that is likely derived from HiFi, which was previously found to have uncharacterized resistance to TJJ (T. Fetch, unpublished data). AAC Justice also

likely carries *Pg13* as this is linked to *Pc91* (Kebede et al. 2020), and may carry *Pg2*, derived from the Furlong parent (Mitchell Fetch et al. 2006).

Other characteristics

SEEDLING (5–9 tiller stage): spring oat, semi-erect to intermediate juvenile growth habit, very sparse pubescence of lower leaf sheath and blade

LEAF (at booting stage): medium green, very sparse pubescence of margin, medium intensity of glaucosity at green stage

CULM: medium hairiness of stem above and below upper node

PANICLE (shortly after heading): medium density, very few hairs or spines on the lowest node

PANICLE BRANCHES: equilateral/symmetrical orientation, horizontal attitude, ranging from 30° to 45° to more than 45° angle between rachis and dominant side branch

SPIKELET: weak to medium glaucosity of glumes, fracture type separation of lower florets, nodding attitude

RACHILLA: medium length between primary and secondary florets, very short grooves, very sparse pubescence

LEMMA: weak to medium glaucosity, small to medium extent of lateral overlap on palea, white to yellow at maturity, absent to very sparse pubescence on lateral and dorsal surfaces, absent to very weak tendency to be awned

KERNEL (primary kernels from upper spikelets): hulled, basal hairs absent, cream, two grains per spikelet, medium density of pubescence on groat

SCUTELLUM: rounded, medium sized

Maintenance and distribution of pedigreed seed stocks

Breeder seed of AAC Justice will be maintained by the Seed Increase Unit, Agriculture and Agri-Food Canada, Experimental Farm, Indian Head, SK S0G 2K0, Canada. Multiplication and distribution of pedigreed seed will be through FP Genetics, 426 McDonald Street, Regina, SK S4N 6E1, Canada.

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