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Source: Canadian Journal of Plant Science, 102(3) : 776-780

Published By: Canadian Science Publishing

URL: https://doi.org/10.1139/CJPS-2021-0276

Canadian Science Publishing

CULTIVAR DESCRIPTION

AAC Excellence oat

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Abstract: AAC Excellence is a covered, spring oat (*Avena sativa* L.) cultivar developed by the Ottawa Research and Development Center (ORDC), Agriculture and Agri-Food Canada (AAFC). It was derived from a four-way cross, OA1250-1/MN07205//Rigodon/HiFi, made in 2009. It has been tested in the Quebec provincial Oat Registration and Recommendation (QCORR) trials since 2017. Based on orthogonal data from the 2018–2021 QCORR trials, AAC Excellence yielded 6% higher than the mean of official checks (AAC Dieter, Canmore, and CS Camden) and its yield was more stable across years than the checks and other cultivars. AAC Excellence had similar levels of test weight and kernel weight to those of the checks, a β-glucan level similar to Akina and better than AAC Nicolas and all checks, and a groat content level similar to AAC Nicolas and AC Dieter and better than Akina and other checks. It had a superior package of yield and quality and is most adapted to Quebec, the Maritimes, and northern Ontario.

Key words: oat, *Avena sativa* L, yield, stability, milling quality.

Résumé : AAC Excellence est une variété d'avoine de printemps (*Avena sativa* L.) vêtue élaborée par le centre de recherche et de développement d'Agriculture et agroalimentaire Canada d'Ottawa. Le cultivar dérive du quadruple croisement OA1250-1/MN07205//Rigodon/HiFi, réalisé en 2009. Il est testé aux essais d'homologation et de recommandation du Québec depuis 2017. Selon les données orthogonales relevées entre 2018 et 2021, le rendement d'AAC Excellence dépasse le rendement moyen des témoins officiels (AAC Dieter, Canmore et CS Camden) de 6 % et est plus stable que celui de ces témoins et d'autres cultivars, d'une année à l'autre. AAC Excellence a un poids spécifique et un grain de même poids que les témoins. Sa concentration de β-glucane est similaire à celle relevée chez Akina, mais dépasse celle d'AAC Nicolas et des témoins. Sa teneur en gruau ressemble à celle d'AAC Nicolas et d'AC Dieter, mais est supérieure à celle d'Akina et des autres témoins. Enfin, AAC Excellence se caractérise par un rendement et une qualité plus élevés, et est mieux acclimatée au Québec, aux provinces maritimes et au nord de l'Ontario. [Traduit par la Rédaction]

Mots-clés : avoine, *Avena sativa* L, rendement, stabilité, qualité meunière.

Introduction

AAC Excellence is a covered spring milling oat (*Avena sativa* L.) cultivar developed by the Ottawa Research and Development Center (ORDC), Agriculture and Agri-Food Canada (AAFC). It was released in 2019 and granted registration by the Canadian Food Inspection Agency (CFIA) on 13 Nov. 2020, with the registration number #9161. It has been tested in the Quebec provincial Oat Registration and Recommendation (QCORR) trials since 2017 and showed superior yield and quality. This article

Received 13 December 2021. Accepted 25 January 2022.

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documents the breeding process that led to the development of AAC Excellence and its performance in yield, agronomic, and quality characteristics, in comparison to a set of official checks and popular cultivars.

Pedigree and Breeding Process

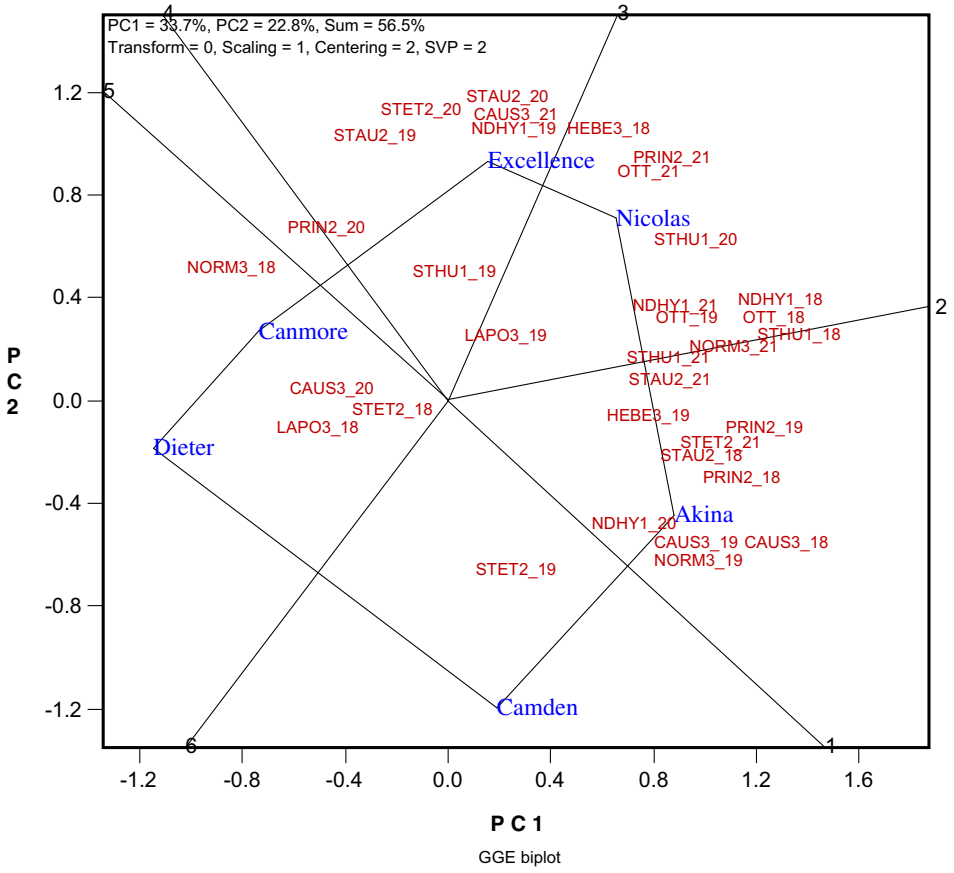
AAC Excellence was developed from the four-way cross 09S03 [$(OA1250\text{-}1/MN07205)_{F1}/(Rigodon/HiFi)_{F1}$]. The last cross was made in May 2009 at ORDC. OA1250-1 was an ORDC line registered as AAC Roskens in 2012, which was early and good in β-glucan and groat percentage. MN07205 was an oat line from the University of Minnesota with good lodging resistance and crown rust resistance at the time when the cross was made. AC Rigodon was an AAFC oat cultivar, well known for its long-standing, superior adaptation to the northern part of eastern Canada. HiFi (McMullen et al. 2005) was a cultivar developed by North Dakota State University, well-known for its high β-glucan content and good crown rust resistance due to *Pc91*, which was defeated a few years later.

Seeds from 123 F_1 plants were grown as 123 F_2 single rows of 3.5 m long in 2010. About three panicles were harvested from visually selected rows, which were grown as 185 F_3 hills in 2011. Sixty-eight $F_{3:4}$ lines were selected from these hills and grown as four-row observation plots in 2012. Twenty-five of these $F_{3:5}$ lines were visually selected for plant characteristics in the field; 14 of these were maintained after visual selection for grain characteristics and advanced to the 2013 Home Test at Ottawa ON, Harrington PE, and Normandin QC, with two replicates. Four of these ($F_{3:6}$) lines were selected to enter into the 2014 Preliminary/ENCORE trials, under the names of OA1415-1 to OA1415-4, which were conducted at 10 locations (Brandon MB, Fargo ND, Harrington PE, Lacombe AB, New Liskeard ON, Normandin QC, Ottawa ON, Palmerston ON, Princeville QC, and Saskatoon SK) with two or three replicates. The first two lines were advanced to the ORDC oat registration trials in 2015, which were conducted at 10 locations across Canada (Brandon MB, Dundalk ON, Harrington PE, Lacombe AB, La Pocatière QC, New Liskeard ON, Normandin QC, Ottawa ON, Palmerston ON, and Princeville QC), with three or four replicates. OA1415-2 (09S03-54-7) was relatively tall but yielded well so it was entered into the 2016 to 2018 QCORR trials coordinated by RGCQ (Regroupement des Gestionnaires et Copropriétaires du Québec). The QCORR trials are conducted annually at nine locations representing the three agro-ecological zones of Quebec. The QCORR trial is also conducted at Ottawa ON since 2007, which has similar cultivar responses to zone 1 of Quebec. In December 2018, OA1415-2 was supported for registration by RGCQ. On 13 Nov. 2020, it was given grant registration by CFIA as AAC Excellence, with the registration number #9161.

Table 1. Yield, agronomic, and quality characteristics of AAC Excellence from the 2018-2021 Quebec Oat registration and Recommendation trials.

	Grain Yield											
Name	kg ha^{-1}	% of check mean	Test weight (kg hl^{-1})	1000-kernel weight (g)	β-glucan (%)	Groat (%)	Oil (%)	Protein (%)	Lodging (0-9)	Days to heading	Days to maturity	Height (cm)	Crown rust (0-9)
AAC Excellence	5095	106	52.9	40.2	4.8	73.3	8.1	13.4	2.8	59.7	91.2	95.1	1.8
CS Camden (CK)	4851	101	51.4	38.9	4.6	71.9	7.6	14.0	2.1	57.4	86.5	80.2	2.3
Canmore (CK)	4862	101	52.1	40.2	4.5	72.1	7.6	14.1	2.5	59.9	89.2	92.7	3.1
AC Dieter (CK)	4716	98	52.4	40.1	4.0	73.4	6.1	13.9	2.7	60.4	88.5	91.6	3.9
Check Mean	4810	100	52.0	39.8	4.4	72.5	7.1	14.0	2.4	59.2	88.1	88.2	3.1
Akina	5019	104	49.8	38.5	4.9	72.6	7.6	13.3	1.9	56.0	87.6	78.6	1.9
AAC Nicolas	5039	105	49.9	36.0	4.4	73.4	6.4	13.2	2.2	62.1	89.1	83.0	3.7
Number of trials	34		34	34	8	25	8	8	23	3	30	34	2
LSD (P = 0.05)	93		0.6	0.9	0.3	0.7	0.4	0.6	0.8	2.1	1.2	1.9	2.2

Fig. 1. Genotypic main effect plus genotype by environment interaction (GGE) biplot to show the relative yield of each cultivar in each of the environments (trials). The trials are indicated by the location codes and the last two digits of the year. The locations are: CAUS3, Causapscal; HEBE3, Hébertville; LAPO3, La Pocatière; NDHY1, Notre-Dame de Saint-Hyacinthe; NORM3, Normandin; OTT, Ottawa (Ontario); PRIN2, Princeville; STAU2, Saint-Augustin; STET2, Saint-Etieene; STHU1, Saint-Huber. The number following the location code indicates the zone the location belongs. "Scaling = 1 & Centering = 2" means the biplot was based on trial-standardized data. [Colour online.]

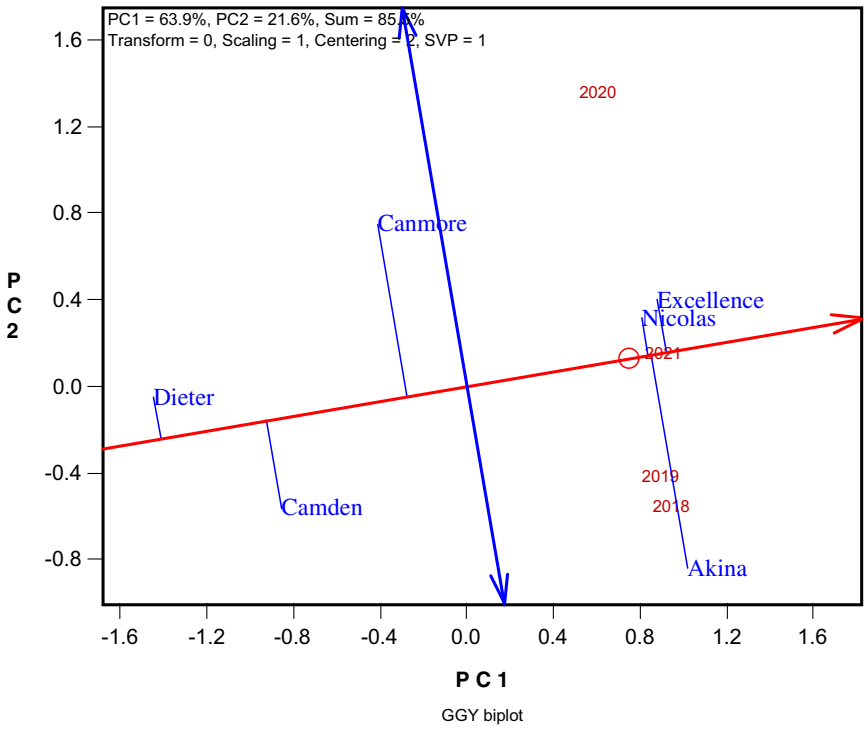


Fifty F_7 panicles were randomly chosen from the 2014 seed plot of OA1415-2, and were grown as 50 hill plots in 2015. Eighteen of these were selected and grown as four-row plots of 3.5 m long in 2016 and then longer four-row strips in 2017. Five of these $F_{7:9}$ lines were selected for better emergence, better crown rust resistance, and shorter plant height. The bulk of these five lines was used to represent OA1415-2 for testing in the QCORR trials in 2018 and thereafter, and for producing pre-Breeder Seed in 2018 and then Breeder Seed in 2019.

Yield

AAC Excellence was first entered into the QCORR trials in 2017. It yielded 9% higher than the mean of the checks, which were AC Rigodon, AC Dieter, and Synextra (data not presented). However, presented in Table 1 are the mean values across the 2018–2021 QCORR trials including those conducted at Ottawa, ON, because 2018 was the year when one of the current official checks, CS Camden, was first tested in QCORR. The mean values of AAC Excellence are compared with those of the three current official checks, AC Dieter, Canmore, and CS Camden, as well as the two currently most popular cultivars, Akina and AAC Nicolas (Yan et al. 2016), in Quebec. Mean values across three replicates in each trial were used for across-trial analysis, treating each trial as a "replicate." Across the 34 trials (location-year combinations), AAC Excellence yielded 6% higher than the mean of the checks, significantly higher than each check. It also yielded slightly higher than Akina and AAC Nicolas (Table 1). Although not statistically significant in mean yield, AAC Excellence was quite different from Akina in its pattern of adaptation. The GGE (genotypic main effect plus genotype by environment interaction) biplot in Fig. 1 shows the relative yield of each cultivar in each of the trials. The polygon view of the biplot divides the trials into sectors, and the cultivar placed on the vertex of a sector is the nominal winner (highest yielder) in the trials that fall in the sector (Yan 2014). Thus, AAC Excellence was the highest yielder in a set of trials where Akina yielded only moderately well, and vice versa (Fig. 1). The trials did not group by

Fig. 2. Genotypic main effect plus genotype by year interaction (GGY) biplot to show mean and stability of the cultivars across years in grain yield. "Scaling = 1 & Centering = 2" means the biplot was based on year-standardized data. The mean across trials each year for each genotype was calculated on trial-standardized data. [Colour online.]



locations, indicating that the genotype by environment interactions were random, unrepeatable, and mainly driven by genotype by year interaction and (or) genotype by location by year three-way interaction. Therefore, it becomes important to compare cultivars of similar mean yield for their stability across years. Presented in Fig. 2 is the GGY (genotypic main effect plus genotype by year interaction) biplot. The red line with a single arrow passes through the biplot origin and the "average year"; it can be referred to as the "average year axis" and the arrow points to higher mean yield across years. The blue line with arrows on both ends passes through the biplot origin and is perpendicular to the average year axis. It indicates instability across years and the arrows on either direction point to higher instability (Yan 2014). Thus, the biplot shows that AAC Excellence, AAC Nicolas, and Akina had similar mean yields, which were clearly higher than those of the checks Canmore, CS Camden, and AAC Dieter, and that the yields of AAC Excellence and AAC Nicolas were clearly more stable than that of Akina, which yielded very well in 2018 and 2019 but not so well in 2020.

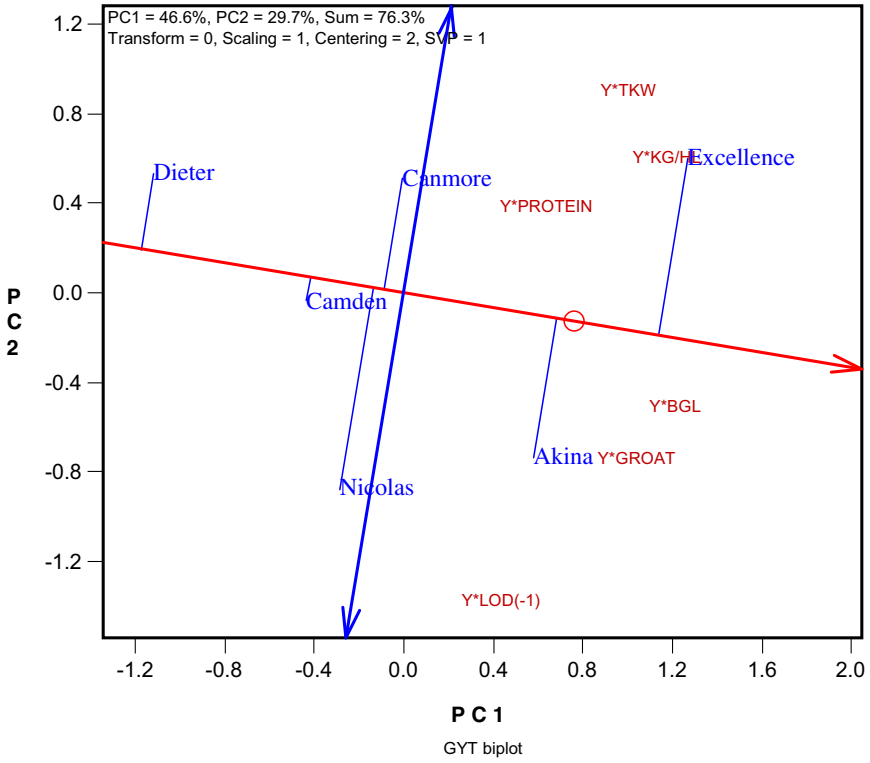
Agronomic Traits and Resistance to Crown Rust

AAC Excellence had similar days to heading as the mean of the checks but was 3 d later in maturity (Table 1). It was taller than the checks but was not significantly more prone to lodging (Table 1). It was more resistant to crown rust than the checks though not statistically significant (Table 1). Crown rust is not a major yield limiting factor in the majority of the oat growing regions in Quebec, the Maritimes, and northern Ontario but is a limiting factor in other regions such as southern Ontario.

Grain, Milling, and Nutritional Quality

AAC Excellence had similar levels of test weight and kernel weight to the checks, a similar level of β-glucan to Akina, which was higher than Nicolas and the checks, and a similar groat percentage to AAC Nicolas and AC Dieter, which was higher than Akina and other checks (Table 1). Thus, AAC Excellence had a trait package that was superior to all tested checks and cultivars in terms of mean yield, yield stability, kernel weight, test weight, β-glucan, and groat percentage. AAC Excellence had a similar level of protein to AAC Nicolas and Akina, which was lower than the official checks. It had a higher oil content than the checks and cultivars but was within the allowance for milling oat (<8.5%). The genotype by yield-trait (GYT) biplot (Yan and Frégeau-Reid 2018) in Fig. 3 shows the superiority of the cultivars in terms of yield-trait combinations. It shows that AAC Excellence was the top cultivar considering the combinations of yield with β-glucan, groat percentage, test weight, kernel weight, protein, and lodging resistance. It also shows that AAC Excellence was relatively strong in combining

Fig. 3. Genotype by yield-trait (GYT) biplot to show the superiority of the cultivars in terms of yield-trait combinations. Y*BGL: yield-β-glucan content combination; Y*GROAT: yield-groat content combination; Y*KG/HL: yield-test weight combination; Y*LOD(-1): yield-lodging resistance combination; Y*PROTEIN: yield-protein content combination; Y*TKW: yield-kernel weight combination. "Scaling = 1 & Centering = 2" means the biplot was based on yield-trait combination-standardized data. [Colour online.]



yield with kernel weight and test weight but relatively weak in combining yield with lodging resistance.

Morphological Characteristics

Seedling growth habit: intermediate
Leaf blade pubescence: sparse
Leaf sheath pubescence: medium
Leaf margin pubescence: sparse
Frequency of plants with recurved leaves: medium
Upper calm node pubescence/hairiness: sparse
Panicle orientation of branches: symmetrical
Panicle density: medium
Panicle attitude of branch position: semi-erect
Lemma color at maturity: white/cream
Lemma tendency to be awned: weak
Lemma awn presence: infrequent
Lemma overlap: medium
Seed width: medium
Groat color: cream
Kernel basal hair presence: medium and short
Groat pubescence: medium
Number of grains per spikelet: two
Scutellum tip shape: pointed
Scutellum size: small to medium

Maintenance and Distribution of Pedigree Seed Stocks

AAC Excellence was licensed to Eastern Grains Inc. The Breeder Seed of AAC Excellence is maintained by the Seed Increase Unit of AAFC at BOX 760, 1 Government Road, Indian Head, SK S0G 2K0, Canada.

Acknowledgements

We thank AAFC and the Canadian Field Crop Research Alliance (CFCRA) for funding the ORDC oat breeding program and for the technical support at the various trial locations.

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