

Flourish hard red winter wheat

R. J. Graf^{1,3}, J. B. Thomas^{1,2}, B. L. Beres¹, D. A. Gaudet¹, A. Laroche¹, and F. Eudes¹

¹Agriculture and Agri-Food Canada, Lethbridge Research Centre, 5403-1st Avenue South, Lethbridge, Alberta, Canada T1J 4B1. Received 9 May 2011, accepted 28 August 2011.

Graf, R. J., Thomas, J. B., Beres, B. L., Gaudet, D. A., Laroche, A. and Eudes, F. 2012. **Flourish hard red winter wheat**. Can. J. Plant Sci. **92**: 183–189. Flourish is a hard red winter wheat (*Triticum aestivum* L.) eligible for all grades of the Canada Western Red Winter wheat class. Compared with the check cultivars in the Western Winter Wheat Cooperative registration trials (CDC Osprey, AC Bellatrix, Radiant, CDC Buteo), Flourish produced similar grain yield with earlier maturity, shorter straw, improved lodging resistance and higher grain protein content. Flourish displayed winter survival similar to the checks. In the eastern prairie rust hazard region of Manitoba and eastern Saskatchewan, Flourish yielded about 5% more grain than CDC Buteo and CDC Falcon, cultivars that are well-adapted and widely grown in the region. Flourish exhibited intermediate resistance to stem and leaf rust combined with moderate resistance to stripe rust and common bunt, a unique combination of disease resistance traits for a western Canadian winter wheat cultivar.

Key words: *Triticum aestivum* L., wheat (winter), cultivar description, doubled haploid, cold tolerance, stem rust, leaf rust, common bunt, milling quality

Graf, R. J., Thomas, J. B., Beres, B. L., Gaudet, D. A., Laroche, A. et Eudes, F. 2012. **Le blé d'hiver roux vitreux Flourish**. Can. J. Plant Sci. **92**: 183–189. Flourish est une variété de blé d'hiver (*Triticum aestivum* L.) roux vitreux admissible à l'ensemble des classes de la catégorie « Blé rouge d'hiver de l'Ouest canadien ». Flourish donne un rendement grainier similaire à celui des cultivars témoins employés dans le cadre des essais coopératifs de l'Ouest sur le blé d'hiver (CDC Osprey, AC Bellatrix, Radiant, CDC Buteo). Il est cependant plus précoce, sa paille est plus courte, il résiste mieux à la verse et la teneur en protéines de son grain est plus élevée. Flourish affiche une résistance à l'hiver analogue à celle des variétés témoins. Dans la partie de l'est des Prairies susceptible à la rouille (Manitoba et est de la Saskatchewan), Flourish a produit environ 5% plus de grain que CDC Buteo et CDC Falcon, des cultivars bien acclimatés à la région et abondamment cultivés. Flourish présente une résistance intermédiaire à la rouille de la tige et des feuilles, et résiste modérément à la rouille jaune du blé ainsi qu'à la carie, combinaison de caractères de résistance unique pour un cultivar de blé d'hiver de l'Ouest canadien.

Mots clés: *Triticum aestivum* L., blé (d'hiver), description de cultivar, double haploïdie, tolérance au froid, rouille de la tige, rouille de feuilles, carie, propriétés à la mouture

Flourish hard red winter wheat (*Triticum aestivum* L.) was developed by Agriculture and Agri-Food Canada (AAFC) at the Lethbridge Research Centre (LRC), in Lethbridge, AB. It is the first Canada Western Red Winter (CWRW) wheat cultivar to combine recommended levels of resistance to stem rust, leaf rust and common bunt. Flourish received registration No. 6982 from the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency on 2011 Mar. 14. An application for Plant Breeders' Rights has been filed.

Flourish is particularly well adapted to the eastern prairie rust hazard area of Manitoba and eastern Saskatchewan and has potential for adoption in the

moister parkland region, where cultivars with early maturity, short straw and excellent lodging resistance are preferred. The name “Flourish” reflects the optimism of western Canadian growers for expansion of the winter wheat crop and is a subtle reference to the excellent end-use quality profile of this cultivar.

Pedigree and Breeding Method

Flourish was selected from the cross RL4746/Blizzard//CDC Kestrel/3/CDC Falcon made at AAFC, LRC, in Lethbridge. The final cross was made in 1997. RL4746 is an experimental hard red spring wheat line with the pedigree Roblin*3/7990-244A, developed at the AAFC Cereal Research Centre. Blizzard is a dwarf bunt

²Current address: Agriculture and Agri-Food Canada, Cereal Research Centre, 195 Dafoe Road, Winnipeg, Manitoba, Canada R3T 2M9.

³Corresponding (e-mail: robert.graf@agr.gc.ca).

Abbreviations: AAFC, Agriculture and Agri-Food Canada; CGC, Canadian Grain Commission; CWRW, Canada Western Red Winter; DH, doubled haploid; GRL, Grain Research Laboratory; LRC, Lethbridge Research Centre; PRCWRT, Prairie Registration Committee for Wheat, Rye and Triticale

(*Tilletia controversa* Kühn in Rabenh.) resistant hard red winter wheat cultivar of complex pedigree, developed by the University of Idaho and the United States Department of Agriculture-Agricultural Research Service, Aberdeen, ID, released in 1989 (Sunderman et al. 1991). CDC Kestrel and CDC Falcon are both registered winter wheat cultivars developed at the University of Saskatchewan, Crop Development Centre, with the pedigrees Norstar*2/Vona and S86-808/Abilene, respectively (Fowler 1997a, 1999). CDC Kestrel and S86-808 were selected from the same cross.

Following greenhouse multiplication of the complex F₁ hybrid, the F₂ seed was inoculated with a mixture of prevalent common bunt [*Tilletia tritici* (Bjerk.) G. Wint. in Rabenh. and *T. laevis* Kühn in Rabenh.] races and vernalized for nine weeks in a dark growth chamber at 1°C. Seedlings were screened at the three leaf stage for reaction to stem rust (*Puccinia graminis* Pers.: Pers. f.sp. *tritici* Eriks. & E. Henn.) and leaf rust (*P. triticina* Eriks.), with 50 resistant plants utilized for doubled haploid (DH) production using the maize hybridization technique (Fedak et al. 1997). Haploid embryos rescued from donor plants exhibiting bunt susceptibility were discarded. In total, 287 DH lines were evaluated in irrigated field observation rows at Lethbridge in 2002 or 2003, in which selection was based on winter survival, plant type and vigour, plant height, straw strength, test weight, protein content, and sodium dodecyl sulphate (SDS) sedimentation volume. Twenty DH lines were produced from the specific F₂ plant from which Flourish was derived. Stem and leaf rust resistance was evaluated in an artificially inoculated nursery grown in collaboration with the University of Manitoba in Winnipeg, MB, from 2003 to 2006. Based on resistance to stem and leaf rust in 2003, a line designated LE1213 was assessed in an irrigated, single replicate preliminary trial at Lethbridge in 2004. Promising agronomic performance, disease resistance, and end-use quality data prompted advancement into replicated trials across western Canada in 2005 and 2006. Based on 10 site-years of replicated pre-registration testing, LE1213 was redesignated W434 in the Western Winter Wheat Cooperative (WWWC) registration trial and evaluated for 3 yr (2007–2009). W434 was recommended for registration by the Prairie Registration Committee for Wheat, Rye and Triticale in February 2010.

Evaluation in the WWC trials was relative to CDC Osprey (Fowler 1997b), AC Bellatrix (Thomas et al. 2012b), Radiant (Thomas et al. 2012a) and CDC Buteo (Fowler 2010). Agronomic trials were grown in Alberta (Beaverlodge, Lacombe, Lethbridge “dry land”, Lethbridge “irrigated”, Vauxhall, Warner), Saskatchewan (Indian Head, Melfort, Saskatoon, Swift Current), and Manitoba (Brandon, Carman) through the collaborative efforts of AAFC, Alberta Agriculture and Rural Development, the University of Saskatchewan and the University of Manitoba. MINITAB was used for the combined mixed model statistical analysis, in

which the effects of environment were considered random and genotypes were fixed (MINITAB Inc. 2007).

During registration testing, resistance to the major diseases of economic importance to winter wheat in both the western and eastern prairies was assessed by AAFC, the University of Manitoba, and the agronomic trial collaborators when differential responses for various pathogens were observed. Adult plant reactions to stem and leaf rust were determined in inoculated field nurseries conducted by the University of Manitoba in Winnipeg. The composite of stem rust races used for 1 or more years included: QTHST (C25), RHTSK (C20), RKQSR (C63), RTHJT (C57), TMRTF (C95), TMRTK (C10) and TPMKR (C53) (Roelfs and Martens 1988; Fetch 2005). Each year, the leaf rust races used for inoculation were a representative mixture collected in western Canada during the previous field season (McCallum and Seto-Goh 2008, 2009; McCallum et al. 2010). Reaction to common bunt was estimated in a nursery conducted by AAFC, LRC staff by inoculating seed with a composite of races that included L1, L16, T1, T6, T13, and T19 (Hoffman and Metzger 1976; Gaudet and Puchalski 1989) and planting into cold soil in October. Stripe rust (*Puccinia striiformis* Westend.) ratings were determined at several sites during the western Canadian epidemic of 2006 (McCallum et al. 2007), one year prior to entry in the registration trials. The reactions to powdery mildew [*Blumeria graminis* (DC.) E.O. Speer] and unspecified leaf spotting pathogens were recorded by trial collaborators at naturally infected test sites expressing differential symptoms.

End-use quality was evaluated at the Canadian Grain Commission (CGC), Grain Research Laboratory (GRL), following protocols of the American Association of Cereal Chemists. The grain used for these analyses was a composite sample consisting of unequal quantities of grain from those test sites where the check cultivars met top grades and produced a mean protein concentration of approximately 12.5%, which is a desired target for the marketing of CWRW wheat. Grain from test sites with serious down-grading factors was not included in the quality composite.

Performance

The agronomic performance of Flourish was based on data collected from 24 sites over 3 yr across the Canadian prairies; fewer data were available for comparisons with CDC Buteo, as it was added as a check cultivar in 2009, the final year of merit evaluation. Although it is not a registration check for the CWRW wheat class, data for CDC Falcon have been reported and are pertinent because it has been the predominant winter wheat cultivar in the eastern prairies for several years (Canadian Wheat Board 2010). CDC Falcon had been included in the WWC registration trials as a high-yielding Canada Western General Purpose wheat check for the eastern prairies.

Overall (2007–2009), the grain yield of Flourish did not differ significantly from the check cultivars (Table 1). However, on a regional basis, the mean yield was equal to or higher than all of the checks in the rust hazard area of Manitoba and eastern Saskatchewan (Zone 4), including CDC Buteo and CDC Falcon, which are adapted stem and leaf rust resistant cultivars. Although it was lower yielding than the CWRW wheat checks in the parkland (Zone 2), Flourish was similar in yield to CDC Falcon, where its early maturity, short straw and excellent lodging resistance have been important factors in its popularity.

Flourish exhibited winter survival similar to the check cultivars (Table 2). Compared with the CWRW checks, Flourish was earlier to reach heading and maturity; it was similar to CDC Falcon for both characteristics. Flourish was 10–13 cm shorter than the CWRW checks, but 4 cm taller than CDC Falcon. Straw strength, as measured by the lodging score, was significantly improved over the checks except for Radiant and CDC Falcon, which exhibited straw strength similar to Flourish.

The test weight of Flourish was similar to CDC Osprey, Radiant and CDC Falcon, but significantly lower than AC Bellatrix and CDC Buteo (Table 3). Kernel mass was significantly heavier than CDC Osprey, CDC Buteo and CDC Falcon, and similar to AC Bellatrix and Radiant. Flourish exhibited grain protein content significantly higher than CDC Osprey, Radiant and CDC Falcon; protein yield per hectare was similar for Flourish and the CWRW checks, statistically higher than CDC Falcon.

The Disease Evaluation Team of the Prairie Recommending Committee for Wheat, Rye and Triticale (PRCWRT) considered Flourish to be intermediate in resistance to stem and leaf rust, and moderately resistant to common bunt (Table 4). Flourish is the first Canadian winter wheat cultivar to combine recommended levels of resistance to stem rust, leaf rust and common bunt. In 2006, Flourish demonstrated moderate resistance to stripe rust (*Puccinia striiformis* Westend.) during the Canadian prairie epidemic (McCallum et al. 2007), based on ratings from three agronomic trials in Alberta. Flourish had reactions to powdery mildew infection that were equal to the best checks; the ratings for leaf spotting diseases were within the range of the check cultivars.

Three years of extensive end-use quality testing by the CGC, GRL and evaluation by the PRCWRT Quality Evaluation Team established that Flourish was equal to the CWRW check cultivars, with noted improvements in protein content and dough strength (Table 5). It was recommended that Flourish be included as a CWRW end-use quality check in all 2011/2012 registration trials. Flourish is eligible for all grades of CWRW wheat.

Table 1. Grain yield (t ha⁻¹) of Flourish compared with the check cultivars, Western Winter Wheat Cooperative registration trials (2007–2009)

Cultivar	Zone ^y	2007 ^z				2008				2009				2007–2009							
		1	2	3	4	Mean	1	2	3	4	Mean	1	2	3	4	Mean					
CDC Osprey		5.17	4.51	—	4.68	4.84	6.14	4.15	—	5.55	5.68	5.48	3.51	2.97	6.51	5.31	5.60	4.24	2.97	5.72	5.24
AC Bellatrix		5.03	4.27	—	4.83	4.73	6.02	4.48	—	5.87	5.76	5.15	4.24	2.75	6.11	5.10	5.43	4.31	2.75	5.68	5.15
Radiant		4.87	4.63	—	4.74	4.76	6.73	4.78	—	5.77	6.18	5.43	2.77	2.44	5.73	4.84	5.70	4.29	2.44	5.46	5.20
CDC Buteo ^x		—	—	—	—	—	—	—	—	—	—	5.40	2.62	2.92	6.03	4.98	—	—	—	—	—
CDC Falcon		5.67	3.90	—	5.16	4.97	6.53	4.95	—	5.88	6.12	5.52	3.31	2.28	5.84	4.96	5.94	3.99	2.28	5.66	5.30
Flourish		5.40	3.85	—	5.33	4.87	6.31	4.65	—	5.87	5.95	5.07	3.41	1.75	6.35	4.92	5.64	3.93	1.75	5.92	5.20
LSD (<i>P</i> ≤ 0.05) ^w		0.56	0.90	—	0.69	0.46	0.74	0.47	—	0.90	0.50	0.72	0.62	0.54	0.81	0.45	0.38	0.60	0.54	0.43	0.27
No. of tests		4	3	0	2	9	4	1	0	2	7	3	1	1	3	8	11	5	1	7	24

^zAll means are weighted by the number of tests.

^yZone 1: Southern Alberta sites (Lethbridge “dry land”, Lethbridge “irrigated”, Vauxhall, Warner).

Zone 2: Parkland sites (Beaverlodge, Lacombe, Melfort).

Zone 3: Semi-arid prairie site (Swift Current).

Zone 4: Eastern prairie rust hazard sites (Brandon, Carman, Indian Head, Saskatoon).

^xCDC Buteo was not included in the 2007 and 2008 trials.

^wLeast significant difference includes variation from the genotype by environment interaction.

Table 2. Agronomic performance of Flourish compared with the check cultivars, Western Winter Wheat Cooperative registration trials (2007–2009)

Cultivar	Winter survival (%)		Heading ^z (d)		Maturity ^z (d)		Height (cm)		Lodging ^y (1–9)	
	2009	2007–2009	2009	2007–2009	2009	2007–2009	2009	2007–2009	2009	2007–2009
CDC Osprey	73	85	175.8	174.3	221.9	216.0	89.5	92.4	4.6	3.7
AC Bellatrix	75	85	177.6	176.3	224.6	219.0	84.8	90.3	3.8	3.4
Radiant	73	84	176.6	175.4	225.4	220.3	85.7	88.7	2.9	2.5
CDC Buteo ^x	75	–	176.0	–	223.6	–	86.7	–	4.0	–
CDC Falcon	72	84	174.8	173.2	219.9	214.8	69.5	74.5	3.1	2.9
Flourish	69	83	174.2	172.8	220.0	215.0	73.7	79.2	2.9	2.6
LSD ($P \leq 0.05$) ^w	8	3	2.0	0.7	2.0	1.1	3.3	2.0	0.8	0.4
No. of tests	6	16	5	17	7	18	6	19	2	10

^zDays to heading and maturity expressed as day of year.^yLodging scale: 1 = all plants vertical, 9 = all plants horizontal.^xCDC Buteo was not included in the 2007 and 2008 trials.^wLeast significant difference includes variation from the genotype by environment interaction.

Other Characteristics

Seedling Characteristics

Coleoptile anthocyanin colouration: slightly reddish.
Intensity of anthocyanin colouration: moderately weak.
Juvenile growth habit: prostrate.
Pubescence of lower leaf sheath: very slight.
Pubescence of lower leaf blades: glabrous.
Colour of lower leaf blade: medium to dark green.
Tillering capacity (at low densities): medium high.

Plant Characteristics at Booting

Growth habit: semi-erect.
Flag leaf colour: dark green.
Pubescence of flag leaf blade: glabrous.
Waxiness of lower side of flag leaf blade: slight.
Waxy bloom of flag leaf sheath: medium-strong.
Pubescence of flag leaf sheath: glabrous.
Flag leaf width: medium.
Flag leaf length: medium short.
Frequency of plants with recurved/drooping flag leaves: medium low.
Flag leaf attitude: intermediate to upright.
Anthocyanin colouration of flag leaf auricles: medium.
Pubescence of flag leaf auricle margins: moderate.

Plant Characteristics after Heading

Shape of culm neck: straight.
Waxiness of culm upper internode: medium weak.
Pubescence of culm upper internode: glabrous.
Pubescence of rachis margins: strongly pubescent.
Anthocyanin colouration of straw at maturity: absent.
Pith in cross-section of straw (at middle of internode below the neck): hollow.
Stem colour at maturity: light yellow.

Spike Characteristics

Shape: tapering.
Attitude at maturity: inclined.
Density: medium.
Length: medium short.
Waxy bloom: weak to medium.
Colour at maturity: white.
Awnedness: awned.
Length of awns at tip of spike: shorter than spike.
Awn colour: yellow.
Awn attitude: intermediate to strong spreading.
Supernumary spikelets: absent.
Hairiness of convex surface of apical rachis segment: absent or very sparse.

Lower Glume Characteristics

Width: medium-wide.
Length: medium-long.
Pubescence: very slight.
Shape of shoulder: very slightly sloping.
Shoulder width: narrow to medium.
Shape of beak: slight to moderately curved.

Table 3. Seed characteristics of Flourish compared with the check cultivars, Western Winter Wheat Cooperative registration trials (2007–2009)

Cultivar	Test weight (kg hL ⁻¹)		Kernel mass (mg)		Grain protein ^z (%)		Protein yield (kg ha ⁻¹)	
	2009	2007–2009	2009	2007–2009	2009	2007–2009	2009	2007–2009
CDC Osprey	78.5	78.4	33.1	30.9	12.0	12.0	625	631
AC Bellatrix	79.7	79.7	35.7	34.7	12.3	12.5	626	645
Radiant	79.3	78.8	36.1	34.3	12.0	11.9	567	622
CDC Buteo ^y	80.5	–	33.9	–	12.3	–	600	–
CDC Falcon	78.7	78.7	32.4	30.3	11.5	11.3	563	600
Flourish	78.7	78.6	36.6	34.6	12.5	12.4	607	644
LSD (<i>P</i> ≤ 0.05) ^x	0.7	0.5	1.3	0.9	0.4	0.3	52	34
No. of tests	8	23	8	23	8	23	8	23

^zGrain protein content determined using whole grain NIR analysis.

^yCDC Buteo was not included in the 2007 and 2008 trials.

^xLeast significant difference includes variation from the genotype by environment interaction.

Beak length: medium short.
 Internal imprint: small.
 Extent of internal hairs: medium sparse.
 Colour at maturity: yellow.

Crease width: mid-wide.
 Crease depth: mid-deep.
 Phenol reaction: brown.

Kernel Characteristics

Type: hard red.
 Colour: medium red.
 Size: mid-size.
 Length: medium.
 Width: medium.
 Shape: elliptical to ovate.
 Cheek shape: rounded.
 Length of brush hairs: mid-long.
 Size of brush: mid-size.
 Germ shape: oval.
 Germ size: small to mid-size.

Maintenance and Distribution of Breeder Seed

Although Flourish is a cultivar developed through DH methodology, a traditional approach was taken to produce Breeder Seed. Breeder lines were derived from random head selections taken from a rogued increase plot in Lethbridge in 2008; these head rows were grown under isolation in 2008/2009. Following the elimination of rows showing any type of variability or contamination, 110 lines were harvested individually and subsequently grown as 4 row plots in Indian Head. One breeder line was eliminated in summer 2010 on account of height variability. The remaining 109 breeder lines were then inspected by the Canadian Food

Table 4. Disease reactions of Flourish compared with the check cultivars, Western Winter Wheat Cooperative registration trials (2007–2009)^z

	Year	CDC Osprey	AC Bellatrix	Radiant	CDC Buteo ^y	CDC Falcon	Flourish
Stem rust ^x	2007	60 S	60 S	20 S	–	5 R-MR	10 I
	2008	50 S	50 S	50 S	–	5 R-MR	10 MR
	2009	60 S	60 S	50 S	30 MS-S	20 MR	10 I
Leaf rust ^x	2007	80 S	10 MS	35 MS-S	–	15 I	25 MS
	2008	50 S	20 MS-S	40 S	–	10 MR	10 I
	2009	30 S	20 S	20 S	30 I	20 I	30 I
Common bunt ^x	2007	66 VS	14 MR	35 S	–	58 VS	10 MR
	2008	67 VS	7 R	62 VS	–	58 VS	30 S
	2009	36 S	9 R	39 S	77 S	46 VS	18 MR
Powdery mildew ^w	2007	4.7	4.0	5.0	–	3.3	3.3
	2008	3.7	3.0	4.0	–	3.0	2.7
	2009	4.3	3.0	2.7	3.0	2.7	2.7
Leaf spots ^y	2007	4.2	3.2	4.1	–	5.4	4.2
	2008	–	–	–	–	–	–
	2009	2.0	1.5	3.2	2.0	2.7	1.8
Stripe rust ^w	2006	4.0	7.2	1.8	–	3.2	3.8

^zStripe rust reaction from 2006 pre-registration trials in Alberta.

^yCDC Buteo was not included in the 2007 and 2008 trials.

^xPercent infection and type of reaction: R=resistant, MR=moderately resistant, I=intermediate, MS=moderately susceptible, S=susceptible, VS=very susceptible.

^wRated using a 1–9 scale: 1=disease free, 9=very severe symptoms.

^ySpecific leaf spotting pathogens were not determined.

Table 5. Mean end-use quality characteristics^z of Flourish and check cultivars, Western Winter Wheat Cooperative registration trials (2007–2009)

Cultivar	Test years	Wheat Protein (%)	Flour Protein (%)	Protein Loss (%)	Hagberg falling no. (s)	Amylograph peak viscosity (BU)	Flour Yield (%)	Flour Ash (%)	Flour Colour (Agtron)	Starch Damage (%)	Farinograph			Remix-to-peak bake		
											Absorption (%)	DDT ^y (min)	Stability (min)	Absorption (%)	Peak time (min)	Loaf volume (cm ³)
CDC Osprey	2007–2009	12.2	11.5	0.7	410	660	76.8	0.36	87.3	5.8	57.2	8.3	21.0	57.7	4.1	845
AC Bellatrix	2008–2009	12.8	12.1	0.7	403	433	75.6	0.39	81.0	6.6	63.3	6.6	12.3	61.0	4.5	853
Radiant	2008–2009	12.4	11.5	0.9	413	595	77.1	0.37	88.5	6.5	59.1	7.5	16.8	61.0	5.7	878
CDC Buteo	2009	12.7	11.8	0.9	405	435	76.4	0.34	81.0	6.2	60.0	7.3	11.5	61.0	4.4	840
Check Mean ^x	2007–2009	12.4	11.7	0.7	414	580	76.3	0.37	85.5	6.3	59.9	7.8	17.5	59.6	4.2	838
Flourish	2007–2009	12.6	11.9	0.8	427	762	76.0	0.37	84.0	5.8	60.1	7.8	25.5	60.7	3.9	877
SD ^w		0.1	0.1	0.1	15	5	0.3	0.01	0.9	0.1	0.2	0.4	1.4	0.0	0.1	14

^zAmerican Association of Cereal Chemists methods were followed by the CGC, GRL for determining the various end-use quality characteristics on a composite of several locations per year

^yFarinograph dough development time.

^xGrand mean of end-use quality check means from 2007–2009.

^wStandard deviation is based on repeated testing of Allis mill check samples and standard bake flour samples with replicate tests performed over an extended period of time each year. Values provided by the CGC, GRL.

Inspection Agency in cooperation with the Canadian Seed Growers' Association. Bulk harvest of the plots produced 1333 kg of cleaned Breeder Seed. The AAFC Seed Increase Unit at Indian Head, SK, will maintain the Breeder Seed of Flourish. All other classes of pedigreed seed will be multiplied and distributed by SeCan Association, 501–300 March Road, Kanata, ON, Canada K2E 2E2.

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