

REQUEST FOR SUPPORT TO REGISTER DT2009

Crop kind: Spring durum wheat **Type:** Canada Western Amber Durum
Triticum turgidum L. var. durum

Proposer: Y. Ruan
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Swift Current

Experimental Designations: DT2009, A1311-GS05

Origin and Breeding:

DT2009 was selected from the cross AAC Congress/Transcend made in 2013 at the Swift Current Research and Development Centre, Swift Current, SK. AAC Congress is a Canadian cultivar derived from the cross DT789/DT790. Transcend, a widely grown Canadian variety, is derived from the cross of DT707/DT696. In 2013, F₁ seeds were increased in the greenhouse. In 2014 seeds of the F₂ were space planted in a disease epiphytotic field nursery near Swift Current. Individual plants were selected for leaf spot resistance, leaf and stem rust resistance, plant height, straw strength, and maturity. F₃ seeds of individual spikes from 231 selected F₂ plants were grown in 2 m long rows near Lincoln, New Zealand, in 2014-2015. Rows were selected relative to the checks for plant height, straw strength and maturity. Of these, 115 selected F₃ lines were harvested individually and the F₄ generation was grown in unreplicated 2.74 m² four-row plot agronomic trials under dryland conditions near Swift Current and Indian Head in 2015. The F₅ generation consisted of 25 families each with 7 lines per family, established from threshed spikes selected prior to harvest from the agronomic trials in Swift Current, grown as 2 m long head-rows near Leeston, New Zealand. F₅ families were selected on the basis of F₄ agronomic performance (yield, height, maturity, straw strength, test weight, kernel weight), quality testing (protein, pigment and gluten strength) and disease reaction (primarily leaf spots and Fusarium head blight). Selection within families was based primarily on the expression of plant height, straw strength, and maturity in the Leeston nursery. In 2016, 73 selected F₆ lines were grown in four-row plots under dryland conditions near Swift Current and Saskatoon and under irrigation at Lethbridge. Selection was based on agronomic performance (similar to F₄ generation), quality traits (protein, pigment, gluten strength, milling performance), and disease resistance (leaf spots and Fusarium head blight). This procedure identified the line A1311-GS05 which met all of the selection criteria at each stage of selection. In 2017, A1311-GS05 was tested in the Durum Western 'A' test. Leaf and stem rust reactions were assessed at MRDC, AAFC (MB), loose smut was assessed at SCRDC, AAFC (SK), and leaf spot reaction was noted within the yield plots at Swift Current, Indian Head and Saskatoon, SK. Fusarium head blight (FHB) was assessed in nurseries near Brandon, MB, Carman, MB, Morden, MB and Ottawa, ON. Quality assessments were done at SCRDC, AAFC and CDC-University of Saskatchewan, SK; testing included grain protein content, gluten properties, milling performance, dough and semolina colour, and Hagberg falling number. A1311-GS05 was entered in the Durum Registration Test as DT2009 from 2018 to 2020.

The 78 Breeder Lines originate from random F_{4:8} single plants of DT2009 grown as 108 pre-Breeder-Lines in 3 m long rows in isolation near Swift Current in 2019, and as 15 m rows near Indian Head in 2020. Approximately 92 kg of Breeder Seed is available for distribution. Breeder seed will be maintained by the Seed Increase Unit of the Research Farm, Indian Head, SK, S0G 2K0.

Performance and Adaptation:

Area of adaptation: Durum growing area of Canada

Strengths: FHB resistance superior to other durum cultivars and comparable to the bread wheat cultivar AAC Viewfield which is rated intermediate for FHB resistance. Combination of high yielding with high wheat protein and semolina protein concentrations equal to Strongfield, and strong straw equal to Brigade with similar plant height to AAC Cabri. Low grain cadmium content.

Weaknesses:

Description:

In three years of registration testing, DT2009 yielded similar to the highest yielding check Brigade (Table 1). Averaged over 28 station years across two zones, grain yield of DT2009 was 0.8% less than Brigade. While averaged over 22 station years in the major durum growing region (Zone 2), DT2009 yielded 0.8% more than Brigade. Grain protein concentration of DT2009 was similar to Strongfield and significantly higher than Brigade (Table 2).

Time to maturity, plant height and test weight of DT2009 were similar to AAC Cabri and within the range of the checks (Table 3). Straw strength of DT2009 was the same as Brigade, the strongest strawed check (Table 3). Kernel size of DT2009 was within the range of the checks and larger than AAC Cabri (Table 3).

DT2009 expressed resistance to leaf rust, stem rust and stripe rust while expressing resistance to intermediate resistance to common bunt, and resistance to moderately susceptible to loose smut (Table 4). DT2009 also demonstrated moderate resistance to Ug99 stem rust (Supplementary Table 1). Fusarium head blight symptom of DT2009 had ratings from moderately resistant (three ratings) to intermediate (three ratings) (Table 5a). Deoxynivalenol (DON) of DT2009 was rated from moderately resistant (one rating), intermediate (two ratings) to moderately susceptible (three ratings) (Table 5b), in which DON levels of moderately susceptible ratings were close to those of intermediate ratings. DT2009 expressed a comparable level of resistance to FHB as the bread wheat cultivar AAC Viewfield which is used as a check in registration trials of CWRS (Tables 5a, 5b and 5c). AAC Viewfield is assigned an overall intermediate FHB resistance rating.

DT2009 had low grain cadmium concentration similar to Strongfield, and its quality profile met the requirements of the CWAD class with the same wheat protein and semolina protein concentrations as Strongfield on average (Tables 6a, 6b and 6c). The Quality Evaluation Team rated DT2009 equal to the checks in both 2018 and 2019 (Table 7).

Table 1. Grain yield (kg ha⁻¹) of DT2009 and check cultivars in the Durum Registration Test, 2018-2020 in Zones^a 1 and 2.

	2018			2019			2020			2018-2020		
	Zone 1	Zone 2	Mean	Zone 1	Zone 2	Mean	Zone 1	Zone 2	Mean	Zone 1	Zone 2	Mean
AC Navigator	4841	4174	4333	4247	4637	4556	4484	4598	4573	4529	4491	4496
Brigade	5598	4191	4540	5706	5201	5306	5425	4901	5007	5580	4833	4978
Strongfield	4891	4023	4236	5007	4909	4938	5338	4839	4924	5085	4650	4727
AAC Cabri	4965	4299	4463	5235	5248	5249	4897	4566	4624	5026	4755	4805
Mean of Checks	5074	4172	4393	5049	4999	5012	5036	4726	4782	5055	4682	4752
DT2009	4978	4200	4391	5367	5309	5324	5353	4845	4943	5245	4874	4937
LSD ^b _{0.05}	536	341	287	681	375	320	708	242	228	353	304	293
No. of tests	2	6	8	2	7	9	2	9	11	6	22	28

^aZone 1 (Black Soils): Indian Head, Brandon.

Zone 2 (Brown and Dark Brown Soils): Swift Current, Stewart Valley (2019, 2020), Saskatoon, Lethbridge, Scott, Hodgeville, Moose Jaw (2020), Pense (2018, 2019), Brooks (2018), Vauxhall (2020).

^bLeast significant difference, $P \leq 0.05$, includes the appropriate genotype by environment interaction variation.

Table 2. Percent grain protein concentration (13.5% moisture basis) of DT2009 and check cultivars measured on grain samples bulked across replications at each location of the Durum Registration Test, 2018-2020 in Zones^a 1 and 2.

	2018			2019			2020			2018-2020
	Zone 1	Zone 2	Mean	Zone 1	Zone 2	Mean	Zone 1	Zone 2	Mean	Mean
AC Navigator	13.4	14.2	14.0	12.9	12.9	12.9	14.0	13.5	13.6	13.5
Brigade	13.3	14.5	14.2	12.0	13.4	13.1	13.4	13.9	13.8	13.7
Strongfield	14.6	14.7	14.6	13.0	14.0	13.8	14.7	14.2	14.3	14.2
AAC Cabri	13.7	14.7	14.4	11.5	13.3	12.9	14.5	14.0	14.1	13.8
DT2009	13.8	14.9	14.6	11.8	13.6	13.2	14.4	14.3	14.3	14.1
LSD ^b _{0.05}	0.9	0.5	0.4	1.2	0.5	0.5	1.1	0.4	0.4	0.3
No. of tests	2	7	9	2	7	9	2	9	11	29

^aZone 1 (Black Soils): Indian Head, Brandon.

Zone 2 (Brown and Dark Brown Soils): Swift Current, Stewart Valley (2019, 2020), Saskatoon, Lethbridge, Scott, Hodgeville, Moose Jaw (2020), Pense (2018, 2019), Brooks (2018), Vauxhall (2020).

^bLeast significant difference, $P \leq 0.05$, includes the appropriate genotype by environment interaction variation.

Table 3. Agronomic characteristics of DT2009 and check cultivars in the Durum Registration Test, 2018-2020.

	Days to maturity ^{a,b}			Test Weight (kg hL ⁻¹) ^a			1000-kernel	Height	Lodging
	Zone 1	Zone 2	Mean	Zone 1	Zone 2	Mean	Wt (g) ^a	(cm) ^a	(1-9) ^c
AC Navigator	98.2	100.2	99.8	80.3	81.9	81.6	46.5	76	2.0
Brigade	99.1	100.8	100.4	80.6	80.7	80.7	44.0	94	1.5
Strongfield	96.8	98.4	98.0	81.0	81.0	81.0	44.0	87	2.2
AAC Cabri	99.5	99.6	99.4	81.0	81.4	81.4	41.8	91	2.6
DT2009	98.7	99.9	99.5	81.0	81.3	81.3	42.8	92	1.5
LSD ^d _{0.05}	2.4	0.9	0.8	1.2	0.7	0.8	1.4	3	0.8
No. of tests	4	19	23	6	23	29	29	29	7

^aZone 1 (Black Soils): Indian Head, Brandon.

Zone 2 (Brown and Dark Brown Soils): Swift Current, Stewart Valley (2019, 2020), Saskatoon, Lethbridge, Scott, Hodgeville, Moose Jaw (2020), Pense (2018, 2019), Brooks (2018), Vauxhall (2020).

^bAll Zone 1 and Zone 2 locations except Stewart Valley, Brandon (2018, 2020), Scott (2018, 2020), Brooks (2019), Vauxhall (2020).

^cStraw strength rated on a scale of 1 indicating that all plants in plot are erect to 9 indicating that all plants in a plot are lying horizontal. Values are means of Pense (2018), Hodgeville (2018), Scott (2019), Saskatoon (2020), Stewart Valley (2020), Swift Current (2020), Vauxhall (2020).

^dLeast significant difference, $P \leq 0.05$, includes the appropriate genotype by environment interaction variation.

Table 4. Summary of disease reactions to stem rust, leaf rust, stripe rust, common bunt and loose smut of DT2009 and check cultivars grown in the Durum Registration Test, 2018-2020.

	Year	Stem rust								Stripe rust					
		Brandon ^d		Morden		Leaf rust		Common Bunt		Loose Smut		LB ^c		CT ^c	
		Rtn ^a	Rxn ^b	Rtn ^a	Rxn ^b	Rtn ^a	Rxn ^b	Rtn ^a	Rxn ^b	Rtn ^a	Rxn ^b	Rtn ^a	Rxn ^b	Rtn ^a	Rxn ^b
AC Navigator	2018	10	I	1	R	0	R	0	R	14	R	4	R	5	-
	2019	10	MR	1	R	2	R	2	R	43	MS	13	MR	5	R
	2020	-	-	1	R	0	R	-	-	70	S	5	R	-	-
Brigade	2018	5	MR	1	R	0	R	0	R	9	R	28	I	1	-
	2019	1	R	1	R	10	R	0	R	39	MS	13	MR	1	R
	2020	-	-	1	R	0	R	-	-	71	S	70	S	-	-
Strongfield	2018	1	R	1	R	0	R	0	R	13	R	8	R	1	-
	2019	5	MR	1	R	0	R	5	R	31	MS	8	R	35	I
	2020	-	-	1	R	0	R	-	-	70	S	5	R	-	-
AAC Cabri	2018	5	MR	10	MR	0	R	0	R	0	R	5	R	1	-
	2019	1	R	1	R	2	R	10	MR	4	R	5	R	1	R
	2020	-	-	1	R	0	R	-	-	93	S	5	R	-	-
DT2009	2018	5	MR	1	R	0	R	2	R	9	R	4	R	1	-
	2019	3	R	1	R	0	R	25	I	19	I	10	R	1	R
	2020	-	-	1	R	0	R	-	-	56	MS	5	R	-	-

^aRtn = rating as % infection.

^bRxn, Reaction type: VR, very resistant; R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.

^cLB, Lethbridge; CT, Creston.

^dStem rust nursery at Brandon which had very high infection e.g. Hoffman 90S.

Supplementary Table 1: Reaction to Ug99 stem rust of DT2009 and check cultivars grown in nurseries near Njoro, Kenya 2017-2019.

	Ug99 Stem Rust					
	2017		2018		2019	
	Sev ^a	Rxn ^b	Sev	Rxn	Sev	Rxn
Napoleon	10	R	1	R	10	MR
AC Navigator	10	M	30	MR	20	MR
Brigade	2	RMR	5	RMR	20	MR
Strongfield	30	RMR	10	RMR	30	MRMS
AAC Cabri	10	RMR	10	RMR	1	MR
DT2009	5	R	10	MR	5	MR

^aSev, Severity: scored on a 0-100 scale.

^bRxn, Reaction type: R, resistant; MR, moderately resistant; RMR, resistant to moderately resistant; M=MRMS, intermediate having both MR and MS type; MS, moderately susceptible; MSS, moderately susceptible to susceptible; S, susceptible.

Table 5a. Summary of response to Fusarium head blight (FHB) disease: FHB symptoms of DT2009 and check cultivars grown in the Durum Registration Test, 2018-2020.

	Carman						Morden					
	2018		2019		2020		2018		2019		2020	
	Index ^a	Rxn ^b	Index	Rxn	Index	Rxn	Index	Rxn	Index	Rxn	Index	Rxn
AC Navigator	38.0	S	54.2	S	40.6	I	41.3	S	55.4	S	39.8	S
Brigade	13.9	I	23.3	I	12.3	MR	13.3	MR	32.1	I	6.3	R
Strongfield	31.3	MS	45.9	MS	52.0	MS	42.5	S	50.4	S	33.0	MS
AAC Cabri	36.0	S	39.9	MS	27.8	I	30.7	MS	39.7	MS	11.1	MR
AAC Viewfield ^c	8.9	MR	28.4	I	30.8	I	20.2	I	40.5	MS	12.6	MR
DT2009	12.4	MR	23.3	I	15.3	MR	20.2	I	28.6	I	8.0	MR

^aFusarium head blight index: [(mean percent incidence X mean percent severity)/100].

^bRxn, Reaction type: R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.

^cCheck and FHB index were derived from Central Bread Wheat Registration Test (CBWC), 2018-2020.

Table 5b. Summary of response to Fusarium head blight (FHB) disease: Deoxynivalenol (DON) concentrations of DT2009 and check cultivars grown in the Durum Registration Test, 2018-2020.

	Carman						Morden					
	2018		2019		2020		2018		2019		2020	
	DON ^a	Rxn ^b	DON	Rxn	DON	Rxn	DON	Rxn	DON	Rxn	DON	Rxn
AC Navigator	23.6	S	56.0	S	38.4	S	33.9	S	33.7	S	44.3	S
Brigade	9.5	MS	21.8	S	28.3	MS	7.2	I	11.5	MR	22.2	MS
Strongfield	13.9	S	23.3	S	16.8	I	19.6	S	25.6	S	32.7	MS
AAC Cabri	16.2	S	23.2	S	22.8	MS	17.7	MS	21.8	MS	22.0	MS
AAC Viewfield ^c	4.3	I	6.9	MR	8.9	I	6.3	I	18.4	MS	23.6	MS
DT2009	8.8	MS	14.6	MS	21.2	MS	9.5	I	13.7	I	13.2	MR

^aDON=Deoxynivalenol in parts per million.

^bRxn, Reaction type: R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.

^cCheck and DON were derived from Central Bread Wheat Registration Test (CBWC), 2018-2020.

Table 5c. Summary of response to Fusarium head blight (FHB) disease: *Fusarium*-damaged kernels (FDK) and ISD of DT2009 and check cultivars grown in the Durum Registration Test, 2018-2020.

	FDK ^a			ISD ^b			
	Carman			Carman		Morden	
	<u>2018</u>	<u>2019</u>	<u>2020</u>	<u>2018</u>		<u>2018</u>	
	%	%	%	Score	Rxn ^c	Score	Rxn
AC Navigator	9.1	20.8	25.4	16.9	S	23.1	S
Brigade	3.3	12.7	23.4	7.6	MS	5.9	I
Strongfield	7.3	13.2	13.3	10.8	MS	14.5	S
AAC Cabri	5.8	11.5	12.6	12.3	S	13.0	MS
AAC Viewfield ^d	1.6	8.4	6.0	4.1	I	5.7	I
DT2009	4.5	8.3	12.1	7.1	MS	7.6	I

^aFDK= *Fusarium*-damaged kernels; rating as % of damaged kernels.

^bISD (incidence, severity, DON) calculated as (0.2*mean incidence) + (0.2*mean severity) + (0.6* DON) for a given entry.

^cRxn, Reaction type: R, resistant; MR, moderately resistant; I, intermediate; MS, moderately susceptible; S, susceptible.

^dCheck, FDK and ISD were derived from Central Bread Wheat Registration Test (CBWC), 2018-2020.

Table 6a. End-use suitability of DT2009 and checks of the 2018 Durum Registration Test based on testing at GRL-CGC.

Checks & Test Lines	Grade	Cd	Soundness & physical			Milling performance ^a			Protein content		Gluten strength		Semolina pigment & pasta colour		
			FN	Test Weight	HVK	Milling Yield	Semo Yield ^b	Semo Ash	Wht Pro	Semo Pro	GI	P/L	TYP	Pasta colour (85°C, Buhler)	
	CWAD ^d	ppb	sec	kg/hl	%	%	%	%	%	%	%	%	ppm	b*	a*
AC Navigator	No.1	271	520	83.0	94	76.2	68.1	0.65	14.4	13.3	62	0.90	10.3	66.9	4.6
Brigade	No.1	95	435	81.9	89	74.7	66.5	0.66	14.7	13.4	82	0.78	10.7	66.4	4.7
Strongfield	No.1	109	420	82.4	95	75.6	66.9	0.62	15.2	13.9	66	0.85	9.4	64.2	4.3
AAC Cabri	No.1	90	445	82.6	95	76.6	66.0	0.64	15.1	13.8	62	0.70	11.1	67.7	4.6
Mean of checks ^c	--	141	455	82.5	93	75.8	66.9	0.64	14.9	13.6	68	0.81	10.4	66.3	4.5
DT2009	No.1	113	475	82.1	91	74.7	66.3	0.63	15.2	14.2	70	0.80	11.3	66.7	5.4

^aA 70% extraction semolina was used for semolina testing.

^b>183 microns.

^cMean of all checks for physical, milling, colour and spaghetti quality.

^dCWAD, Canada Western Amber Durum; Cd, cadmium; ppb, parts per billion; FN, falling number; HVK, hard vitreous kernels; Semo, semolina; Wht, Wheat; Pro, protein; GI, gluten index; P/L, Alveograph P/L; TYP, Total yellow pigment.

Table 6b. End-use suitability of DT2009 and checks of the 2019 Durum Registration Test based on testing at GRL-CGC.

Checks & Test Lines	Grade	Cd	Soundness & physical			Milling performance ^a			Protein content		Gluten strength		Semolina pigment & pasta colour		
			FN	Test Weight	HVK	Milling Yield	Semo Yield ^b	Semo Ash	Wht Pro	Semo Pro	GI	P/L	TYP	Pasta colour (85°C, Buhler)	
	CWAD ^d	ppb	sec	kg/hl	%	%	%	%	%	%	%	%	ppm	b*	a*
AC Navigator	No.3	197	370	82.7	87	76.8	68.5	0.66	12.9	11.8	84	0.68	9.3	63.4	4.7
Brigade	No.1	63	335	81.7	85	74.7	65.9	0.66	13.3	12.2	94	0.49	9.2	62.4	4.4
Strongfield	No.3	71	270	81.7	91	75.3	66.3	0.65	14.0	12.9	82	0.67	8.7	60.8	5.0
AAC Cabri	No.3	55	320	83.1	86	75.0	66.2	0.64	13.3	12.1	73	0.47	9.5	64.0	4.3
Mean of checks ^c	--	97	324	82.3	87	75.5	66.7	0.65	13.4	12.3	83	0.58	9.2	62.7	4.6
DT2009	No.1	71	300	82.5	94	74.8	66.7	0.66	13.7	12.6	85	0.50	10.5	65.2	4.7

^aA 70% extraction semolina was used for semolina testing.

^b>183 microns.

^cMean of all checks for physical, milling, colour and spaghetti quality.

^dCWAD, Canada Western Amber Durum; Cd, cadmium; ppb, parts per billion; FN, falling number; HVK, hard vitreous kernels; Semo, semolina; Wht, Wheat; Pro, protein; GI, gluten index; P/L, Alveograph P/L; TYP, Total yellow pigment.

Table 6c. End-use suitability of DT2009 and checks of the 2020 Durum Registration Test based on testing at GRL-CGC.

Checks & Test Lines	Grade	Cd	Soundness & physical			Milling performance ^a			Protein content		Gluten strength		Semolina pigment & pasta colour		
			FN sec	Test Weight kg/hl	HVK %	Milling Yield %	Semo Yield ^b %	Semo Ash %	Wht Pro %	Semo Pro %	GI %	P/L	TYP ppm	Pasta colour (85°C, Buhler) b* a*	
AC Navigator	No.2	261	495	82.7	95	76.3	67.6	0.69	13.7	12.8	73	0.73	10.5	67.2	4.1
Brigade	No.2	80	485	81.5	95	74.3	65.9	0.70	13.8	12.9	94	0.63	10.7	66.1	3.5
Strongfield	No.1	93	475	82.4	94	75.2	66.3	0.65	14.4	13.3	82	0.57	9.5	64.6	2.7
AAC Cabri	No.1	72	475	82.2	93	74.3	65.3	0.67	14.3	13.3	72	0.53	10.9	67.7	3.1
Mean of checks ^c	--	127	483	82.2	94	75.0	66.3	0.68	14.0	13.1	80	0.62	10.4	66.4	3.3
DT2009	No.1	91	445	82.5	97	74.9	66.4	0.68	14.5	13.7	77	0.48	11.4	67.2	4.0

^aA 70% extraction semolina was used for semolina testing.

^b>183 microns.

^cMean of all checks for physical, milling, colour and spaghetti quality.

^dCWAD, Canada Western Amber Durum; Cd, cadmium; ppb, parts per billion; FN, falling number; HVK, hard vitreous kernels; Semo, semolina; Wht, Wheat; Pro, protein; GI, gluten index; P/L, Alveograph P/L; TYP, Total yellow pigment.

Table 7. Quality Evaluation Team Voting record.

	Years In Test	Rating			
		Support	Do Not Object	Object	Abstain
DT2009	2019	15	5	1	0
	2018	0	20	3	0