

NRG010 General Purpose spring wheat

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DePauw, R. M., Knox, R. E., Singh, A. K., McCaig, T. N., Clarke, J. M. and Cuthbert, R. D. 2013. **NRG010 General Purpose spring wheat**. *Can. J. Plant Sci.* **93**: 549–555. Based on 26 trials over 2 yr, the cultivar NRG010 yielded similar to the General Purpose checks Hoffman and AC Andrew. NRG010 had significantly shorter stature than Hoffman. NRG010 had a large white kernel intermediate in size to AC Andrew and Hoffman. NRG010 expressed resistance to prevalent races of leaf rust, stem rust and common bunt, and moderate susceptibility to prevalent races of loose smut and fusarium head blight. NRG010 is eligible for the Canada General Purpose wheat class.

Key words: *Triticum aestivum* L., cultivar description, grain yield, disease resistance

DePauw, R. M., Knox, R. E., Singh, A. K., McCaig, T. N., Clarke, J. M. et Cuthbert, R. D. 2013. **Le blé de printemps de fins générales NRG010**. *Can. J. Plant Sci.* **93**: 549–555. Au terme de 26 essais réalisés en deux ans, le cultivar NRG010 a donné un rendement similaire à celui des témoins de fins générales Hoffman et AC Andrew. NRG010 se caractérise par une taille significativement plus courte que Hoffman. La variété donne de gros grains blancs dont le calibre se situe entre celui de AC Andrew et de Hoffman. NRG010 résiste aux races courantes de rouille de la feuille, de rouille de la tige et de carie, et est modérément sensible aux races fréquentes du charbon nu et de la brûlure de l'épi causée par *Fusarium*. NRG010 est admissible à la classe du blé canadien de fins générales.

Mots clés: *Triticum aestivum* L., description de cultivar, rendement grainier, résistance aux maladies

NRG010, a hard white spring wheat (*Triticum aestivum* L.), was developed at the Semiarid Prairie Agricultural Research Centre (SPARC), Agriculture and Agri-Food Canada (AAFC), Swift Current, SK. It received registration No. 6877 from the Variety Registration Office, Plant Production Division, Canadian Food Inspection Agency on 2010 Sep. 08. NRG010 was granted Plant Breeders' Rights No. 4064 by the Plant Breeders' Rights office, Canadian Food Inspection Agency 2011 May 20.

Pedigree and Breeding Method

NRG010 derives from the cross ND2710/HY459//AC Vista made in 2001 at the Semiarid Prairie Agricultural Research Centre (SPARC) of Agriculture and Agri-Food Canada, Swift Current, SK. ND2710 (Frohberg et al. 2004) derives from the cross Sumai3/Wheaton//Grandin. HY459 derives from the cross HY396/8021-V2//AC Vista. The top cross parent AC Vista (DePauw et al. 1998) derives from the cross HY344/7915-QX76B//HY358*3/Bt10. In 2002, about 10 000 F₂ seed were inoculated with common bunt [*Tilletia laevis* Kühn in Rabenh., and *T. tritici* (Bjerk.) G. Wint. in Rabenh.] races L1, L16, T1, T6, T13 and T19 (Hoffmann and Metzger 1976). The seed was planted in 90-m-long rows which were 23 cm apart with alternate rows planted with

CDC Kestrel winter wheat (Fowler 1997), which is susceptible to leaf rust (*Puccinia triticina* Eriks.) and stem rust (*P. graminis* Pers.:Pers. f.sp. *tritici* Eriks. & E. Henn.). Every 10th row was planted to genotypes susceptible to prevalent races of leaf and stem rust. An epiphytotic nursery was established by needle inoculating a sample of plants in each row of the susceptible genotypes with representative rust races found the previous year (McCallum and Seto-Goh 2006). Stem rust races used were: QTHST (C25), RHTSK (C20), RKQSR (C63), RTHJT (C57), TMRTK (C10) and TPMKR (C53) (Roelfs and Martens 1988; Fetch 2005). About 600 disease-free, strong-stemmed and early-maturing individuals were selected, threshed and composited after selecting for kernel characteristics. The composite was designated C0104S. A subset of about 2000 F₂ plants was grown to assess response to *Fusarium graminearum* Schwabe [teleomorph *Gibberella zeae* (Schwein. Petch)] in a nursery near Portage la Prairie, MB. About 300 spikes were selected which expressed low incidence of FHB, and those which had low levels of fusarium damaged kernels were composited and designated C0104P. In the F₃ generation, 6000 seeds from the C0104S and 3900 seeds from C0104P were

Table 1. Grain yield (kg ha⁻¹) of NRG010 compared with the check cultivars in the 2006 Western Hard White Wheat B-test

Entry	Swift Current	Regina	Indian Head	Leth-bridge	Kernen	Brandon	Mean ^z
CDC Teal	2753	2073	3413	6630	3649	4363	3806
Infinity	2865	2270	3712	5283	3756	4621	3752
Snowbird	2672	2625	3476	6636	3560	4444	3915
AC Vista	3617	2327	5267	5757	4982	4316	4371
Snowwhite475	2941	1741	4232	4368	4043	4625	3678
NRG010	3354	2999	5334	8209	5058	5978	5156
CV	4.0	6.1	6.0	4.1	4.4	6.3	5.1
LSD _{0.05}	209	304	454	494	332	536	437

^zMean is based on LS means procedure of SAS software.

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

grown in thinly planted 50-m long rows near Lincoln, New Zealand. Plants with shorter stronger stature were selected and threshed in bulk. In the F₄ generation, about 7000 seeds from C0104S subpopulation and 7000 seeds from the C0104P subpopulation were inoculated with common bunt and grown as individual plants in a rust epiphytotic nursery similar to the F₂ nursery at SPARC near Swift Current. About 200 disease-free, strong-stemmed, and early maturing individuals were selected from each subpopulation, threshed and selected for kernel characteristics. In the F₅ generation, 182 selections from C0104P and 179 selections C0104S lines were grown out in a plant progeny 2-m-long row near Irwell, New Zealand, and selected for time to maturity, plant height and straw strength. In the F₆ generation, 76 lines of subpopulation C0104P and 81 lines of subpopulation C0104S were grown in replicated trials to assess agronomic performance near Swift Current and Indian Head, SK, and Morden, MB. In the F₇ generation, 19 families from C0104P and 25 families

from C0104S each at two to five lines per family were grown out near Irwell, New Zealand, and selected using the same criteria as for the F₅ generation. In the F₈ generation, 27 lines from C0104P and 44 lines from C0104S were grown in replicated trials to assess agronomic performance near Swift Current, Indian Head and Morden. In the F₆ and F₈ generations, the response to leaf rust and stem rust was assessed in an epiphytotic nursery near Glenlea, MB, and response to FHB was assessed in the FHB nursery near Carman, MB. Seed from the yield trials was used to assess grain quality and kernel characteristics. Selected F₈ lines were screened for reaction to a mixture of races T2, T9, T10 and T39 of loose smut [*Ustilago tritici* (Pers.) Rostr.] (Nielsen 1987) and races L1, L16, T1, T6, T13 and T19 of common bunt. The above procedure resulted in an experimental line C0104P-DQ44 being identified which met all of the selection criteria at each stage of selection.

The experimental line C0104P-DQ44 was evaluated in the Western Hard White "B" test in 2006 and as GP010

Table 2. Grain yield (kg ha⁻¹) of NRG010 compared with the check cultivars in the 2007 High Yield Wheat (HYWC) and 2008 General Purpose Cooperative (GPC) tests

Entry	Yield (Kg ha ⁻¹)										2007–2008
	2007 HYWC ^z					2008 GPC ^y					
	Zone 1	Zone 2	Zone 3	Zone 4	Mean ^x	Zone 1	Zone 2	Zone 3	Zone 4	Mean ^x	
Superb	3102	3834	4388	6310	3951						
AC Crystal	3092	3955	4119	6781	3957						
5701PR	4236	4080	4897	6855	4524						
5702PR	3933	4272	4976	6994	4551						
AC Andrew	3765	4747	5635	8604	4979	5606	5159	7264	9786	6444	5663
Hoffman	4348	4568	5960	7855	5100	6151	5032	7631	7412	6420	5729
BW362						4915	4131	5540	5289	4922	
NRG010	4619	4525	5473	7417	4996	5096	4511	6500	7880	5779	5370
LSD _{0.05}	644	130	287	692	109	674	538	1002	660	494	399
Trials	4	6	4	1	15	3	3	4	1	11	26

^zLocations: Zone 1: Brandon, Indian Head, Rosebank and Souris; Zone 2: Beiseker, Kernen, Regina, Scott, Swift Current and Watrous; Zone 3: Ellerslie, Lacombe, Melfort, Vermilion; Zone 4: Lethbridge irrigated.

^yLocations: Zone 1: Brandon, Indian Head and Rosebank; Zone 2: Regina, Swift Current and Watrous; Zone 3: Ellerslie, Lacombe, Melfort, Vermilion; Zone 4: Lethbridge irrigated.

^xMeans are based on LS means from SAS Proc Mixed.

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

Table 3. Agronomic characteristics of NRG010 compared with the check cultivars in the 2006 Western Hard White B-test

Entry	Maturity (d)	Height (cm)	Lodging ^z (1 to 9)	Volume weight (kg hL ⁻¹)	Seed size (mg)	Seed colour NaOH
CDC Teal	91.9	96	2.1	78.3	31.2	Red
Infinity	91.6	98	2.6	78.9	29.3	Red
Snowbird	92.6	101	2.4	78.7	30.5	White
AC Vista	95.7	79	2.1	77.1	31.7	White
Snowwhite475	92.0	84	2.3	76.7	34.4	White
NRG010	94.8	89	1.8	76.8	34.8	White
LSD _{0.05}	1.2	2.7	0.8	1.1	2.1	
Trials	6	6	4	6	6	

^zStraw 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 horizontally.

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

in the 2007 High Yield Wheat Cooperative test and in the 2008 General Purpose Cooperative test. The 2007 High Yield Wheat Cooperative test consisted of six checks and 36 experimental lines in a 6×7 lattice design with three replications grown at 18 locations in western Canada of which valid data were obtained from 16. The checks were Superb (Townley-Smith et al. 2010), AC Crystal (Fernandez et al. 1998), 5701PR, 5702PR, AC Andrew (Sadasivaiah et al. 2004), and Hoffman. The 2008 General Purpose Cooperative test consisted of three checks and 39 experimental lines in a 6×7 lattice design with three replications grown at 13 locations in western Canada of which valid data were obtained from 11. The checks were AC Andrew, Hoffman and Unity VB (Fox et al. 2010). The variables measured and protocols followed in the co-operative test have been described by Fox and McCallum (2006). The SAS PROC MIXED procedure was used to analyze the data annually and to perform a combined analysis over years using a mixed model with environments and replications considered random and genotypes considered fixed (SAS Institute, Inc. 2003).

Response to diseases was assessed in specialized disease nurseries in 2007 and 2008. Leaf and stem rust seedling infection types were assessed using stem rust races: QTHST (C25), RHTSK (C20), RKQSR (C63), RTHJT (C57), TMRTK (C10) and TPMKR (C53) (Roelfs and Martens 1988; Fetch 2005), and leaf rust races: MBDS (12-3), MBRJ (128-1), MGBJ (74-2), TDBG (06-1-1), TDBJ (70-1), and TBJJ (77-2) (McCallum and Seto-Goh 2006). Field evaluations of leaf and stem rust reactions, using leaf rust races representative of those found the previous year and the same stem rust races as for the seedling tests, were measured annually in epiphytotic nurseries near Glenlea, MB. Reaction to fusarium head blight was assessed in artificially inoculated field tests conducted annually near Glenlea and Carman, MB (Gilbert and Woods 2006). To determine the response to loose smut, a mixture of the prevalent races T2, T9, T10 and T39 was injected into florets at anthesis of plants grown in the field and the inoculated seed subsequently grown out in a greenhouse (Menziez et al. 2003). To determine the response to common bunt, a mixture of prevalent races L1, L16, T1, T6, T13 and T19 was used to inoculate the

Table 4. Agronomic characteristics of NRG010 compared with the check cultivars in the 2007 High Yield Wheat Coop and 2008 General Purpose tests

Entry	Maturity (d)			Height (cm)			Lodging ^z (1 to 9)			Volume weight (kg hL ⁻¹)			Kernel size (mg)		
	2007	2008	2 yr mean ^y	2007	2008	2 yr mean	2007	2008	2 yr mean	2007	2008	2 yr mean	2007	2008	2 yr mean
Superb	94.2			87			1.1			75.5			34.0		
AC Crystal	98.0			84			1.9			75.0			32.3		
5701PR	94.9			81			2.3			74.2			35.1		
5702PR	94.6			85			1.7			73.1			34.4		
AC Andrew	98.8	105.4	101.1	85	86	86	1.2	1.9	1.6	73.6	77.8	75.7	31.5	39.7	35.6
Hoffman	97.8	105.3	100.3	114	102	108	2.6	2.9	2.8	76.2	79.4	77.8	40.0	47.2	43.6
Unity VB		102.2			92						79.8			36.7	
NRG010	97.0	105.1	99.7	86	89	88	1.5	2.5	2.0	74.1	76.8	75.5	34.0	42.4	38.2
LSD _{0.05}	0.5	1.7	2.2	1	3	2	0.5	0.5	0.63	1.1	1.2	1.3	1.3	1.8	2.1
Trials	15	11	26	15	11	26	8	4	12	15	11	26	15	11	26

^zStraw 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 horizontally.

^yMeans are based on LS means procedure of SAS Proc Mixed.

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

Table 5. Disease reactions of NRG010 and check cultivars based on data from 2006 Western Hard White B-test

Disease	Field leaf rust		Stem rust		Stripe rust		Mean
	Severity ^z	Rating ^y	Severity ^y	Response ^x	Regina ^w	Leth-bridge	
Entry							
CDC Teal	30	MR	1	R	5.0	2.3	3.6
Infinity	20	RMR	1	R	8.7	9.0	8.9
Snowbird	40	MR	1	R	6.7	4.2	5.4
AC Vista	50	RMR	7	I	8.8	5.7	7.2
HY475	40	MRMS	7	RMR	8.9	9.1	9.0
GP010	0	R	5	RMR	5.4	3.1	4.3
GP013	5	MR	3	R	1.3	0.7	1.0
LSD _{0.05}					1.2	1.1	1.8
	Bunt		Loose smut		Fusarium head blight		
Entry	Incidence ^v	Rating	Incidence ^u	Rating	Index ^t	Rating ^x	
CDC Teal	20	I	41.46	I	57.75	S	
Infinity	18	I	12.5	MR	45.38	MS	
Snowbird	16	I	34.04	I	36.81	I	
AC Vista	39	VS	50	I	76.31	S	
HY475	4	VR	38.1	I			
GP010	0	VR	58.33	MS	45	MS	
GP013	0	VR	7.143	R			
LSD _{0.05}					37.5		

^zLeaf rust severity as a percent of leaf area affected and rating scale based on percent: 0–10 R, 11–30 MR, 31–39 I, 40–60 MS, >60 S.

^yPercent of the stem infected with stem rust based on modified Cobb scale.

^xDisease rating (or response in the case of stem rust): VR = very resistant, R = resistant, RMR = resistant/moderately resistant, MR = moderately resistant, MRMS is equal to I = intermediate in reaction, MS = moderately susceptible, S = susceptible, and VS = very susceptible.

^wStripe rust ratings scored on field plots at Regina, SK, and Lethbridge, AB, using a 1 = resistant to 9 = susceptible scale.

^vPercentage of plants with common bunt symptoms.

^uPercentage of plants with loose smut symptoms.

^tFusarium head blight disease index = (percentage of infected heads × percentage of diseased florets on infected heads)/100.

^sLeast significant difference, $P \leq 0.05$.

seed planted in mid-April of each year near Lethbridge, AB (Fox and McCallum 2006).

Performance

In the 2006 Western Hard White B test, NRG010 yielded significantly higher (18%, $P \leq 0.05$) than AC Vista, the highest yielding check (Table 1). In the 2007 High Yield Wheat Coop test, NRG010 yielded significantly higher than 5701PR (10%), 5702PR (9.8%) and AC Crystal (26%), and similar to AC Andrew and Hoffman (Table 2). In the 2008 General Purpose Coop, it yielded significantly less than AC Andrew and Hoffman. Based on 26 trials over 2 yr, the yield of NRG010 was not significantly different from AC Andrew and Hoffman. NRG010 had time to maturity similar to AC Vista and was significantly later maturing than the CWRS checks in the 2006 Western Hard White B test (Table 3). Based on 26 tests over 2 yr, the time to maturity of NRG010 was similar to that of Hoffman and AC Andrew (Table 4). NRG010 was significantly taller (9 cm) than AC Vista and significantly shorter than the CWRS checks in the 2006 Western Hard White B test (Table 3). It was significantly shorter (20 cm) than Hoffman and similar to AC Andrew (Table 4). NRG010 had significantly stronger straw than Infinity and was

similar to all of the other checks in the 2006 Western Hard White B test (Table 3). NRG010 was intermediate in lodging score to AC Andrew and Hoffman (Table 4). The test weight of NRG010 was similar to AC Vista and significantly less than the CWRS checks in the 2006 Western Hard White B test (Table 3). NRG010 had similar test weight to AC Andrew and significantly lower than Hoffman (Table 4). The white seed of NRG010 was significantly larger than that of AC Vista in the 2006 Western Hard White B test (Table 3). NRG010 was intermediate in seed size to that of AC Andrew and Hoffman (Table 4).

Other Characteristics

Spike: Oblong to tapering, mid-dense, mid-long to long, inclined to erect, awned; glumes mid-wide to wide, mid-long to long, glabrous, white; glume shoulder primarily sloping to slightly sloping, narrow; glume beak primarily short to mid-long.

Kernel: Color white; large, long to mid-long; mid-wide, ovate, cheeks rounded to angular; brush hairs mid-long to long; crease mid-wide, mid-deep; germ mid-size to large, oval.

Shattering: Resistant to seed shelling due to wind.

Table 6. Disease reactions of NRG010 and check cultivars based on data from 2007 High Yield Wheat Cooperative test

Entry	Leaf rust ^z		Stem rust		Common bunt		Loose smut	
	Severity (%)	Rating	Severity ^y	Response ^x	Incidence ^w (%)	Rating ^x	Incidence ^v (%)	Rating ^x
Superb	73	S	tr	R	11	MR	10	R
AC Crystal	28	MR	tr	R	1	VR	0	R
5701PR	0	R	tr	R	3	VR	30	MR
5702PR	2	R	tr	R	3.5	VR	33	MR
AC Andrew	45	MS	2	RMR	42	VS	60	MS
Hoffman	28	MR	25	MRS	10	MR	0	R
NRG010	2	R	tr	R	1	VR	0	R
Fusarium head blight								
Entry	Glenlea (3 reps)			Carman (3 reps)			Ottawa	
	VRI ^u	Rating ^x	DON ^t (ppm)	VRI	Rating ^x	DON (ppm)	Infection ^s (%)	
Superb	27	I	4.2	24	I	7.0	31	
AC Crystal	60	S	2.1	56	S	13.5	44	
5701PR	32	MS	4.1	8	MR	4.8	29	
5702PR	25	I	3.3	13	MR	3.8	29	
AC Andrew	24	I	1.8	59	S	9.0	55	
Hoffman	52	S	1.1	33	MS	3.3	26	
NRG010	18	MR	3.5	26	I	5.8	18	
LSD _{0.05}				14			11	

^zLeaf rust severity as percent leaf area affected and rating scale based on percent: 0–10 R, 11–30 MR, 31–39 I, 40–60 MS, >60 S.

^yPercent of the stem infected with stem rust based on modified Cobb scale; tr = trace.

^xDisease rating (or response in the case of stem rust): R = resistant, RMR = resistant/moderately resistant, MR = moderately resistant, MRMS is equal to I = intermediate in reaction, MS = moderately susceptible, S = susceptible, and VS = very susceptible.

^wPercentage of plants with common bunt symptoms.

^vPercentage of plants with loose smut symptoms.

^uFusarium head blight disease visual rating index (VRI) = (percentage of infected heads × percentage of diseased florets on infected heads)/100.

^tMycotoxin deoxynivalenol.

^sPercentage of spikes with fusarium head blight symptoms.

^rLeast significant difference, $P \leq 0.05$.

Table 7. Disease reactions of NRG010 and check cultivars based on data from 2008 General Purpose Wheat Cooperative test

Entry	Field leaf rust ^z		Field stem rust		Bunt		Fusarium head blight				
	Portage		Winnipeg		Lethbridge	Saskatoon	Loose smut				
	Severity (%)	Rating	Severity ^y	Response ^x	Infection ^w (%)	Infection ^v (1-9)	Infection ^u (%)	Rating ^x	Mean	Glenlea index ^t	DON ^s (ppm)
AC Andrew	33	I	10	RMR	27	2	59	MS	44	0.1	18
Hoffman	11	MR	90	S	35	5	0	R	13	0.0	5
Unity VB	2	R	10	RMR	1	0	11	R	12	0.5	4
NRG010	2	R	5	R	4	0	10	R	35	1.5	10
LSD _{0.05}					9	–				5.8	

^zLeaf rust severity as percent leaf area affected and rating scale based on percent: 0–10 R, 11–30 MR, 31–39 I, 40–60 MS, > 60 S.

^yPercent of the stem infected with stem rust based on modified Cobb scale.

^xDisease rating (or response in the case of stem rust): R = resistant, RMR = resistant/moderately resistant, MR = moderately resistant, MRMS is equal to I = intermediate in reaction, MS = moderately susceptible, S = susceptible.

^wPercentage of plants with common bunt symptoms.

^vProportion of plants with common bunt symptoms rated on a 1 (low) to 9 (high) scale.

^uPercentage of plants with loose smut symptoms.

^tFusarium head blight disease index = (percentage of infected heads × percentage of diseased florets on infected heads)/100.

^sDeoxynivalenol.

^rLeast significant difference, $P \leq 0.05$.

Disease reaction: NRG010 expressed resistance to prevalent races of leaf rust, stem rust and common bunt in 3 years of testing (Tables 5, 6 and 7). It expressed resistance to prevalent races of loose smut in 2007 and 2008 and moderate susceptibility in 2006. NRG010 appears to have more resistance to Fusarium head blight (FHB) than some of the checks. It had lower FHB disease index than check AC Vista in the 2006 Western Hard White B test. It had lower FHB disease index than Superb, AC Crystal, AC Andrew and Hoffman in the 2007 High Yield Wheat Coop. NRG010 had lower FHB disease index than AC Andrew but not Hoffman in the 2008 General Purpose Coop.

End-use suitability: NRG010 is eligible for grades of Canada Western General Purpose Wheat class.

Maintenance and Distribution of Pedigreed Seed

The 136 Breeder Lines originate from F₆-derived F₁₀ random single plants grown out near Swift Current in 2007, followed by growing out as 160 hill plots near Irwell, New Zealand, and again as 15-m rows near Indian Head in 2008, which generated approximately 210 kg of Breeder Seed. Breeder seed will be maintained by the Seed Increase Unit of the Research Farm, Indian Head, Saskatchewan, Canada S0G 2K0. The cultivar will be added to the “OECD List of Cultivars”.

NRG010 has been released for distribution and multiplication to CANTERRA SEEDS 201 - 1475 Chevrier Boulevard, Winnipeg, Manitoba, Canada R3T 1Y7. Phone +1 (204) 988-9752; Fax +1 (204) 487-7682. www.canterra.com/.

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