CULTIVAR DESCRIPTION

AC2000 hard white spring wheat

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DePauw, R. M., Sadasivaiah, R. S., Clarke, J. M., Fernandez, M. R., Knox, R. E., McCaig, T. N. and McLeod, J.G. 2002. **AC2000 hard white spring wheat**. Can. J. Plant Sci. **82**: 415–419. AC2000 is a hard white spring wheat (*Triticum aestivum* L.) with resistance to preharvest sprouting and prevalent races of common bunt [*Tilletia laevis* Kuhn in Rabenh. and *T. caries* (DC.) Tul. & C. Tul.]. It is eligible for grades of the Canada Prairie Spring (White) wheat class.

Key words: *Triticum aestivum* L., cultivar description, white wheat, bunt resistance, preharvest sprouting resistance, noodle color

DePauw, R. M., Sadasivaiah, R. S., Clarke, J. M., Fernandez, M. R., Knox, R. E., McCaig, T. N. et McLeod, J.G. 2002. **Blé dur blanc de printemps AC2000**. Can. J. Plant Sci. **82**: 415–419. AC2000 est une variété de blé dur blanc de printemps (*Triticum aestivum* L.) résistante à la germination sur pied et aux races courantes de carie [*Tilletia laevis* Kuhn *in* Rabenh. et *T. caries* (DC.) Tul. & C. Tul.]. La nouvelle variété se range dans la catégorie des blés de printemps (blancs) Canada Prairie.

Mots clés: *Triticum aestivum* L., description de cultivar, blé blanc, résistance à la carie, résistance à la germination sur pied, couleur de nouille

AC2000 hard white spring wheat was developed at the Semiarid Prairie Agricultural Research Centre, Agriculture and Agri-Food Canada (AAFC), Swift Current, Saskatchewan. It received an interim registration from the Canadian Food Inspection Agency on 27 June 2000 to facilitate market evaluation by the Canadian Wheat Board.

Breeding Methods and Pedigree

AC2000 derives from the cross AC Taber/SC8021-V2//AC Karma. The final cross was made in 1991 at the Semiarid Prairie Agricultural Research Centre, AAFC, Swift Current. SC8021-V2, a sprouting resistant white-kerneled germplasm line (DePauw et al.1992), was hybridized with AC Taber, a red-seeded semidwarf wheat cultivar with high grain yield potential (Knox et al. 1992). The resulting F_1 hybrid was top-crossed with AC Karma, a white-seeded spring wheat with very good milling properties (Knox et al. 1995). The F_2 seed from the final cross was inoculated with common bunt and grown as individual plants in a leaf rust (*Puccinia recondita* Roberge ex Desmaz.), and stem rust (*P. graminis* Pers.:Pers. f. sp. *tritici* Eries. & E. Henn.) disease nursery near Swift Current. Individual plants were selected for maturity, height, straw strength, and resistance to diseases. The F_3, F_5, and F_7 generations were grown as head rows in a winter nursery near Brawley, California, to multiply seed for early generation tests by harvesting the head-rows on an individual row basis. In F_4, F_6 and F_8 generations, 128, 201 and 74 lines, respectively, were evaluated for quantitative and qualitative traits using early generation screening procedures (DePauw et al. 1989). Reaction to leaf and stem rust was measured in an epiphytotic nursery near Glenlea, Manitoba. Early generation selection for preharvest sprouting resistance was based on intact spikes using protocols described by DePauw and McCaig (1991). Remnant seed from the yield trials was used to assess grain quality and kernel characteristics. Selected F_8 lines were screened for reaction to loose smut [*Ustilago tritici* (Pers.) Rostr.] and common bunt. An experimental line, designated 9127-CJ08C, was evaluated in the High Yielding Wheat 'B' test in 1996. From 1997 to 1999, it was evaluated in the High Yielding Wheat Cooperative test as HY446. The controls were AC Crystal, eligible for grades of Canada Prairie Spring – Red, and AC Karma and AC Vista, eligible for grades of Canada Prairie Spring – White. The variables measured and the protocols for the High Yield Wheat Cooperative test have been described by Graf and Fox (2000). Preharvest sprouting response was measured on intact spikes using protocols described by DePauw and McCaig (1991). Each year, the data were analyzed using S506 statistical program developed by Statistical Research Services, AAFC. SAS GLM was used to perform combined analysis over years using a mixed model with environments

Table 1. Agronomic performance of AC2000 compared to the check cultivars, based on data from the High Yielding Wheat Cooperative Tests (1997–1999)

Cultivar	Yield (t ha^{-1}) Zone 1[z]	Zone 2	Zone 3	Mean[y]	Maturity (d)	Plant height (cm)	Lodging (1–9)[x]	Test weight (kg hL^{-1})	Kernel weight (mg)
AC Crystal	3.316	4.622	5.348	4.404	104.1	85	1.9	78.8	36.2
AC Karma	3.770	4.621	5.416	4.567	102.5	87	2.2	79.1	35.2
AC Vista	4.150	4.657	5.543	4.737	100.3	87	2.4	78.0	40.2
AC2000	3.451	4.516	5.343	4.375	103.7	85	1.7	78.4	36.2
LSD ($P < 0.05$)				0.182	0.6	1	0.4	0.8	0.9
No. of tests	14	18	12	44	38	42	22	45	45

[z]Zone 1, near Brandon, Elgin, Glenlea, Rosebank, MB, and Indian Head, SK; Zone 2, near Irricana, AB, Kernen, Scott, Stewart Valley, Swift Current, SK; Zone 3, near Lacombe, Grand Prairie, AB, and Lake Lenore and Melfort, SK.
[y]All means are weighted by the number of tests within a zone.
[x]1, all plants vertical; 9, all plants horizontal.

and reps considered random and genotypes as fixed (SAS Institute, Inc. 1990).

While in the cooperative tests, reaction to leaf and stem rust was measured in a disease nursery near Glenlea, MB. The stem rust races used were: QFC (75), QTH (C25), RKQ (C63), RRQ (C63), RTH (C57), TMR (C10), TMR (C95) and TPM (C53). The races of leaf rust used were: MBDS, MBR, MBRJ, MCDS, MGB, TJB, TJBJ, TGBJ and 128-1 (74-2) (Kolmer 1999, 2001). Races T2, T9, T10 and T39 of loose smut and races L1, L16, T1, T6, T13 and T19 of common bunt were used to determine response to these diseases. The race designations are those described by Green (1965) and Roelfs and Martens (1988) for stem rust, Long and Kolmer (1989) for leaf rust, Hoffmann and Metzger (1976) for common bunt, and Nielsen (1987) for loose smut. Response to leaf spots caused by several organisms that infect wheat leaves [tan spot *Pyrenophora tritici-repentis* (Died.) Drechs., Stagonospora blotch *Phaeosphaeria nodorum* (E. Muller) Hedjaroude and Septoria tritici blotch *Mycosphaerella graminicola* (Fuckel) J. Schrot. in Cohn] was assessed following the procedures described by Fernandez et al. (1996).

Performance

During 3 yr of testing in the High Yield Wheat Cooperative test, AC2000 yielded similar to AC Crystal and significantly less than AC Karma and AC Vista (Table 1). This was due mainly to its poor performance relative to AC Karma and AC Vista in Zone 1. AC2000 matured slightly earlier than AC Crystal, about 1 d later than AC Karma and 3.4 d later than AC Vista. AC2000 had slightly shorter straw than AC Karma and AC Vista, and the same height as AC Crystal. AC2000 was significantly more lodging resistant than AC Karma and AC Vista and similar in straw strength as AC Crystal. The volume and kernel weight of AC2000 were intermediate to AC Karma and AC Vista. The strong straw of AC2000 would be an advantage for production under irrigated conditions even though it yielded significantly less grain than AC Karma and AC Vista (Table 2).

AC2000 expressed resistance to prevalent races of common bunt (Table 3) and appeared to have improved resistance to loose smut. In growth cabinet loose smut inoculation trials, AC2000 and all of the checks were resistant to races T2, T10 and T39, but susceptible to race T9 (data not shown). AC2000 had better leaf spot resistance than AC Karma and AC Vista. The response of AC2000 to stem rust was comparable to the checks and its leaf rust resistance was less than the checks. AC2000 would not be suitable for the rust area of the eastern prairies.

Table 2. Agronomic performance of AC2000 compared to check cultivars, based on data from the High Yielding Wheat Irrigated Cooperative Tests (1997–1999) grown at Outlook and Swift Current, SK, and Lethbridge and Tempest, AB

Cultivar	Yield (t ha^{-1})	Maturity (d)	Height (cm)	Lodging (1–9)[z]
AC Crystal	6.886	103.1	86	1.3
AC Karma	7.226	102.6	87	1.5
AC Vista	7.169	101.3	89	2.0
AC2000	6.519	103.5	87	1.1
LSD ($P < 0.05$)	0.612	1.4	2	0.5
No. of tests	12	10	11	8

[z]1, all plants vertical; 9, all plants horizontal.

AC2000 had kernel hardness intermediate to AC Karma and AC Vista as indicated by farinograph absorption and starch damage (Table 4), and particle size index (data not shown). AC2000 had milling properties intermediate to AC Karma and AC Vista as demonstrated by flour yield, and its flour color was brighter than all of the checks except AC Karma in 1999. The farinograph dough development time and stability indicated that AC2000 had gluten strength as strong as or stronger than that of AC Vista and much stronger gluten than AC Karma. The remix loaf volume of AC2000 was greater than both AC Karma and AC Vista and similar to AC Crystal. AC2000 exhibited improved brightness and color of raw kansui noodles, 24 h after preparation, than all of the checks (Kruger et al. 1992; Miskelly and Moss 1985). The starch pasting properties of AC2000 were similar to the checks, as indicated by the Rapid Visco-analyzer peak viscosity.

AC2000 had significantly more resistance to preharvest sprouting conditions than AC Karma and Genesis as indicated by the response of intact spikes to sprouting conditions (Table 5). Its preharvest sprouting response was similar to the white-seeded wheats AC Vista, Kenya 321 and Losprout and similar or slightly better than the red-seeded wheat AC Crystal.

Table 3. Disease reactions of AC2000 and check cultivars, based on data from High Yielding Wheat Cooperative Tests (1997–1999)

	Leaf rust[z]			Stem rust[z]		
Entry	1997	1998	1999	1997	1998	1999
AC Crystal	40RMR	80MRMS	40RMR	5RMR	10R	20MR
AC Karma	10RMR	60MRMS	20MRMS	3RMR	1R	10RMR
AC Vista	30MRS	80MRMS	40MRMS	1R	1R	15RMR
AC2000	40MRS	80MS	60MS-S	10MR	1R	20MR
	Bunt[z]			Loose smut[z,y]		
	1997	1998	1999	1997	1998	1999
AC Crystal	3R	–[u]	3R	92HS	75S	0R
AC Karma	2R+	–	2R	0R	33MR	14R
AC Vista	1R+	–	3R	100HS	–	–
AC2000	0R+	–	2R	44MS	0R	15R
	FHB index[x]			Common root rot[w]		
	1997	1998	1999	1997	1998	1999
AC Crystal	66	–	36	5	24	72
AC Karma	83	–	24	16	25	75
AC Vista	84	–	39	8	10	65
AC2000	–	–	22	23	29	71

	Leaf spot[v]				
	1997	1998		1999	
	SC	IH	SC	IH	SC
AC Crystal	6.5	7.0	6.5	7.0	7.0
AC Karma	8.9	9.0	8.0	8.5	8.0
AC Vista	8.3	9.3	8.0	10.0	7.5
AC2000	8.3	8.5	7.8	7.5	7.3

[z]Percent infection and type of reaction: T, trace; R, resistant; VR, very resistant, MR, moderately resistant; I, intermediate resistant; S, susceptible; HS, highly susceptible. Number before the decimal indicates the % infected area using modified Cobb scale (Stakman et al. 1962).
[y]Ratings in 1999 are based on data from current and previous years.
[x]Fusarium Head Blight index = (% infected spikelets × % infected spikes)/100.
[w]Percentage of plants with moderate to large lesions on the subcrown internode.
[v]Rated at the milk dough stage, using a scale of 0–11 (0 is very resistant and 11 is very susceptible). IH = Indian Head, SK, SC = Swift Current, SK.
[u]Not determined.

Other Characteristics

SPIKES: Tapering to oblong, mid-dense, mid-long to long, erect to inclined, awned; glumes mid-wide, mid-long to long, glabrous, white; glume shoulder primarily square to elevated with some sloping; glume beak mid-long.

KERNEL: Color white; mid-large to large, mid-long to long; mid-wide to wide, ovate to elliptical, cheeks rounded to angular; brush hairs long; crease mid-wide to wide, mid-deep to shallow; germ mid-size to small, ovate.

SHATTERING: Resistant, similar to the checks.

PHOTOPERIOD REQUIREMENT: Daylength insensitive.

VERNALIZATION REQUIREMENT: Slight vernalization requirement similar to AC Karma and AC Crystal.

END-USE SUITABILITY: Eligible for grades of Canada Prairie Spring (White) wheat class.

Availability of Propagating Material

Breeder Seed consisted of 126 Breeder Lines that were developed from F_6 -derived F_{10} single plants. They were grown in isolation near Swift Current in 1998 and again as 15-m rows near Indian Head in 1999. Application for Plant Breeders' Rights have been made. AC2000 has been released for distribution and multiplication of pedigreed seed stocks to SeCan Association, 201- 52 Antares Dr., Ottawa, Ontario, Canada K2E 7Z1

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Table 4. Measurements of flour-milling properties, gluten strength, and bread-loaf volume for AC2000 and check cultivars from High Yielding Wheat Cooperative Tests (1997–1999)[z]

	Flour protein (%)			Flour yield (%)			Starch damage (Meg)			Flour color (Ag Col)		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
AC Crystal	11.0	10.7	10.2	76.2	76.3	75.0	6.1	5.9	6.2	73	70	83
AC Karma	11.0	10.6	10.2	78.1	78.7	76.5	6.1	5.7	6.7	79	80	91
AC Vista	11.3	11.0	10.6	75.1	75.5	74.6	7.9	7.8	8.7	77	76	85
AC2000	11.0	11.2	10.1	75.5	75.9	75.2	6.8	6.2	6.7	81	82	89

				Farinograph								
	Rapid Visco-analyzer peak viscosity			Absorption (%)			Dough development (min)			Stability (min)		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
AC Crystal	–[y]	254	251	60.7	59.2	60.5	7.00	6.00	4.25	8.0	9.0	5.5
AC Karma	–	255	247	61.9	60.2	62.1	3.25	2.75	2.50	3.5	3.5	2.5
AC Vista	–	247	244	67.6	67.3	69.3	4.75	4.75	4.00	7.5	7.5	5.0
AC2000	–	243	251	63.0	63.3	64.3	4.75	5.00	4.00	9.0	8.5	5.5

				Raw kansui noodle (Hunter Lab reflectance CIE color scale)								
	Remix loaf volume (cm)			1997			1998			1999		
	1997	1998	1999	L*24	a*24	b*24	L*24	a*24	b*24	L*24	a*24	b*24
AC Crystal	770	790	705	73.4	0.04	27.9	72.8	0.13	29.1	74.6	–0.11	26.0
AC Karma	710	705	610	73.9	0.27	30.1	73.4	0.09	32.5	76.6	–0.06	28.1
AC Vista	745	750	680	75.2	–0.14	28.5	76.0	0.25	29.3	77.8	–0.39	25.8
AC2000	765	785	705	76.7	0.57	31.6	77.7	0.10	30.9	79.2	–0.08	28.4

[z]Data provided by the Grain Research Laboratory of the Canada Grain Commission. Methods standardized by American Association of Cereal Chemists were followed for determining the various end-use suitability traits.
[y]Not determined.

Table 5. Response to sprouting conditions of AC2000, white-seeded parents, and checks

Genotype	Seed color	T1HS[z]	T2HS	T1KS	T2KS	T1AA	T2AA
AC2000	White	8.3	6.3	51	52	2.40	2.11
AC Karma	White	10.0	9.7	79	79	3.88	2.93
AC Vista	White	8.6	8.8	53	60	1.71	2.24
Kenya 321	White	8.1	5.7	46	39	0.84	0.87
Losprout	White	7.9	6.4	42	47	1.41	1.89
Genesis	White	9.9	9.7	95	89	4.65	3.96
SC8021-V2	White	0.9	1.4	15	7	0.18	0.23
AC Crystal	Red	9.0	9.8	53	77	3.34	3.96
Neepawa	Red	4.7	7.9	27	57	1.92	2.72
RL4137	Red	0.1	0.3	2	2	0.08	0.25
LSD ($P < 0.5$)		1.3	1.1	11	10	0.52	0.64

[z]T1HS = percentage of spikes with visible sprouts from heads collected at about 16% moisture on a wet weight basis = Time 1, T2HS = percentage of spikes with visible sprouts collected 10 days after Time 1, T1KS = percentage of kernels sprouted at Time 1, T2KS = percentage of kernels sprouted at Time 2, T1AA = alpha amylase activity (EU g^{-1}) at Time 1, T2AA = alpha amylase activity (EU g^{-1}) at Time 2.

DePauw, R. M. and McCaig, T. N. 1991. Components of variation, heritabilities and correlations for indices of sprouting tolerance and seed dormancy in *Triticum* spp. Euphytica **52**: 221–229.
DePauw, R. M., McCaig, T. N., Clarke, J. M., McLeod, J. G., Knox, R. E. and Fernandez, M. R. 1992. Registration of sprouting-tolerant white-kerneled wheat germplasms SC8019-R1 and SC8021-V2. Crop Sci. **32**: 838.
DePauw, R. M., Townley-Smith, T. F., McCaig, T. N., Clarke, J. M., McLeod, J. G. and Knox, R. E. 1989. HY355 white spring wheat. Can. J. Plant Sci. **69**: 1245–1250.
Fernandez, M. R., Clarke, J. M., DePauw, R. M., and Lefkovitch, L. P. 1996. Comparison of durum and common wheat cultivars for reaction to leaf spotting fungi in the field. Plant Dis. **80**: 793–797.
Graf, R. J. and Fox, S. L. 2000. Subcommittee on wheat rye and triticale draft operating procedures. Pages 20–38 *in* Wheat Rye and Triticale Subcommittee report. Prairie Registration Recommending Committee for Grain.
Green, G. J. 1965. Stem rust of wheat, rye, and barley in Canada in 1964. Can. Plant Dis. Surv. **45**: 23–29.
Hoffmann, J. A. and Metzger, R. J. 1976. Current status of virulence genes and pathogenic races of the wheat bunt fungi in the northwestern USA. Phytopathology **66**: 657–660.
Knox, R. E., DePauw, R. M., McCaig, T. N., Clarke, J. M., McLeod, J. G. and Fernandez, M. R. 1995. AC Karma white spring wheat. Can. J. Plant Sci. **75**: 899–901.
Knox, R. E., DePauw, R. M., Morrison, R. J., McCaig, T. N., Clarke, J. M., and McLeod, J. G. 1992. AC Taber red spring wheat. Can. J. Plant Sci. **72**: 1241–1245.

Kolmer, J. A. 1999. Physiologic specialization of *Puccinia triticina* in Canada in 1997. Plant Dis. **83**: 194–197.
Kolmer, J. A. 2001. Physiologic specialization of *Puccinia triticina* in Canada in 1998. Plant Dis. **85**: 155–158.
Kruger, J. E., Matsuo, R. R. and Preston, K. 1992. A comparison of methods for the prediction of Cantonese noodle color. Can. J. Plant Sci. **72**: 1021–1029.
Long, D. L. and Kolmer, J. A. 1989. A North American system of nomenclature for *Puccinia recondita* f. sp. *tritici*. Phytopathology **79**: 525–529.
Miskelly, D. M. and Moss, J. J. 1985. Flour quality requirements for Chinese noodle manufacture. J. Cereal Sci. **3**: 379–387.
Nielsen, J. 1987. Races of *Ustilago tritici* and techniques for their study. Can. J. Plant Pathol. **9**: 91–105.
Roelfs, A. P. and Martens, J. W. 1988. An international system of nomenclature for *Puccinia graminis* f. sp. *tritici*. Phytopathology **78**: 526–533.
SAS Institute, Inc. 1990. SAS software. Version 5. SAS Institute Inc. Cary, NC.
Stakman, E. C., Stewart, D. M. and Loegering, W. Q. 1962. Identification of physiologic races of *Puccinia graminis* var. *tritici*. U.S.D.A., A.R.S. Bull. E. 617. pp. 1–3.