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CULTIVAR DESCRIPTION

Bhishaj soft white spring wheat

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Randhawa, H. S., Sadasivaiah, R. S., Graf, R. J. and Beres, B. L. 2011. **Bhishaj soft white spring wheat** Can. J. Plant Sci. **91**: 805–810. Bhishaj is a soft white spring wheat (*Triticum aestivum* L.) that meets the end-use quality specifications of the Canada Western Soft White Spring class. Bhishaj is well-adapted to the wheat growing regions of southern Alberta and southern Saskatchewan. Based on data from the Western Soft White Spring Wheat Cooperative Registration Test from 1999 to 2001 and 2006 to 2009, Bhishaj exhibited high grain yield, mid-season maturity, semi-dwarf stature with moderate straw strength, and good resistance to shattering. Bhishaj expressed resistance to the prevalent races of leaf rust, stripe rust and powdery mildew, intermediate response to loose smut, susceptibility to stem rust, common bunt, and *Fusarium* head blight. Based on end-use quality analysis performed at the Grain Research Laboratory of the Canadian Grain Commission, Bhishaj had similar milling and baking performance as the check cultivars AC Reed and AC Phil.

Key words: *Triticum aestivum* L., cultivar description, soft white spring wheat, grain yield, quality, disease resistance

Randhawa, H. S., Sadasivaiah, R. S., Graf, R. J. et Beres, B. L. 2011. **Le blé tendre blanc de printemps Bhishaj**. Can. J. Plant Sci. **91**: 805–810. Bhishaj est une variété de blé tendre blanc de printemps (*Triticum aestivum* L.) respectant les paramètres de qualité établis pour la classe « Blé tendre blanc de printemps de l'Ouest canadien ». Bhishaj est bien acclimaté aux régions du sud de l'Alberta et du sud de la Saskatchewan où l'on cultive le blé. Selon les données issues des essais d'homologation coopératifs sur le blé tendre blanc de printemps entrepris dans l'Ouest de 1999 à 2001 et de 2006 à 2009, Bhishaj se caractérise par un rendement grainier élevé, une précocité de mi-saison, un port demi-nain et une paille modérément robuste, ainsi qu'une bonne résistance à l'égrènement, Bhishaj résiste aux races courantes de rouille des feuilles, de rouille jaune et de blanc; la variété réagit modérément au charbon nu et est sensible à la rouille de la tige, à la carie ainsi qu'à la brûlure de l'épi causée par *Fusarium*. Selon l'analyse de la qualité en fonction de l'usage final effectuée au Laboratoire de recherches sur les grains de la Commission canadienne des grains, Bhishaj a un rendement similaire à celui des cultivars témoins AC Reed et AC Phil pour la mouture et la cuisson.

Mots clés: *Triticum aestivum* L., description de cultivar, blé tendre blanc de printemps, rendement grainier, qualité, résistance aux maladies

Bhishaj (SWS285) is a high-yielding, soft white spring wheat (*Triticum aestivum* L.) cultivar developed by Agriculture and Agri-Food Canada (AAFC), Lethbridge Research Centre (LRC), Lethbridge, AB, and released in 2001. It was assigned registration number 5676 by the Variety Registration Office, Canadian Food Inspection Agency on 2003 Jul. 24. Bhishaj is adapted to the irrigated regions of southern Alberta and southern Saskatchewan, and meets the end-use quality characteristics of the Canada Western Soft White Spring (CWSWS) wheat class.

Pedigree and Breeding Methodology

Bhishaj was developed from the cross ID0236/SWS56// AC Reed made in 1990. ID0236 is a breeding line from the Agricultural Research Service (ARS), USDA, Aberdeen, ID. SWS56 is a selection from an F_4 bulk of an unknown cross from ARS-USDA, Aberdeen, ID. AC Reed (Sadasivaiah et al. 1993) is a soft white spring wheat cultivar released by Agriculture and Agri-Food Canada, Lethbridge. Single head selections were made in the F_2 generation, with the F_3 head rows grown in a winter nursery near Brawley, CA. Promising F_3 head rows were identified based on semi-dwarf stature, high yield potential, and lodging and shattering resistance. Within each of the selected F_3 head rows, desirable heads were threshed individually and examined for kernel colour, the presence of black point, and kernel visual distinguishability characteristics for the class. Seed from the remaining heads was bulked and divided into several F_4 populations at Lethbridge. This process of creating modified bulks was also followed in the F_4 generation. To ensure phenotypic and genotypic uniformity, doubled haploids were then produced from

[1]*Deceased.*

Abbreviations: **CWSWS**, Canada Western Soft White Spring; **DON**, deoxynivalenol; **FHB**, *Fusarium* head blight

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selections from an F_5 bulk (code: 700) using the wheat × maize technique (Orshinsky and Sadasivaiah 1994). Twenty-one doubled haploid lines were evaluated in a preliminary yield test in 1997. In 1998, one of the promising doubled haploid lines (CP-03-04 = DH-426) was evaluated in advanced yield trials as 98B-196. From 1999 to 2001, this line was evaluated in the Western Soft White Spring Wheat Cooperative Tests as SWS285 conducted at four locations in southern Alberta (Lethbridge, Iron Springs, Vauxhall and Bow Island) and two locations in southern Saskatchewan (Saskatoon and Outlook). These locations represent the major irrigated regions of the Canadian prairies. The criteria used for evaluation included grain yield, maturity, plant height, resistance to lodging, shattering and prevalent diseases, and end-use quality characteristics. Soft white spring wheat cultivars AC Reed, AC Phil (Sadasivaiah et al. 1993, 2000) and AC Andrew (Sadasivaiah et al. 2004) were used as checks.

Artificially inoculated field nurseries were used to determine reactions to leaf rust (*P. triticina* Eriks. = *P. recondita* Roberge ex Desmaz.) and stem rust (*Puccinia graminis* Pers.: Pers. f. sp. *tritici* Eriks. & e. Henn.) at the AAFC Cereal Research Centre (CRC), Winnipeg, MB, using the modified Cobb scale (Peterson et al. 1948). Seedling infection type reactions were determined in the greenhouse for leaf rust races MBDS (12-3), MGBJ (74-2), TJBJ (77-2) and MBRJ (128-1) (McCallum and Seto-Goh 2006) and to stem rust races TMRTK (C10), RKQSR (C63), TPMKR (C53) RTHJT (C57), QTHST (C25) and RHTSK (C20) (Roelfs and Martens 1988; Fetch 2005). *Fusarium* head blight tolerance was evaluated at Glenlea, MB, in field nurseries that were spray inoculated with a macroconidial suspension and rated using a visual index (% incidence × % severity/100) as described by Gilbert and Woods (2006). Resistance to loose smut [*Ustilago tritici* (Pers.) Rostr.] was estimated as described by Menzies et al. (2003). Evaluation of common bunt [*Tilletia laevis* Kuhn in Rabenh. and *T. tritici* (Bjerk.) (Bjerk.) R. Wolff] resistance was conducted at the AAFC Lethbridge Research Centre using a composite of races L1, L16, T1, T6, T13 and T19, and planting into cold soil (Gaudet and Puchalski 1989; Gaudet et al. 1993). Reactions to stripe rust (*Puccinia striiformis* Westend) and powdery mildew (*Blumeria graminis* DC. f. sp. *tritici* Em. Marchal) were recorded using a 1–6 scale (1 = resistant; 6 = highly susceptible) based on natural field infection in the registration trials. For leaf spot reaction, disease severity was observed from natural infection in the field.

End-use quality was evaluated by the Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, based on composite samples for each test entry that were prepared from test locations selected on the basis of protein content and grade of the check cultivars. Grain from locations where the checks produced poor-quality grain was not included in the quality composites.

The MIXED procedure of SAS® (Littell et al. 2006) was used to perform yearly and multi-year analyses for agronomic data with years, environments, and their interactions treated as random effects, and cultivar treated as a fixed effect. Mean separation tests were performed using Fisher's protected LSD procedure. For end-use quality data, there were no replicated observations within years; hence standard deviation was reported.

Performance and Adaptation

Based on evaluation in the Western Soft White Spring Cooperative Test, Bhishaj had significantly higher ($P \leq 0.05$) grain yield than the check cultivar AC Reed, but was similar to AC Andrew (Table 1). This was confirmed by the combined analysis over 7 yr (1999–2001, 2006–2009), in which Bhishaj (7.81 t ha^{-1}) yielded 9% more than AC Reed (7.14 t ha^{-1}), but yielded similar to AC Andrew (7.79 t ha^{-1}). Overall, Bhishaj yielded 3% more than AC Andrew in Saskatchewan than in Alberta (Table 1). The physiological maturity of Bhishaj (108d) was intermediate to AC Reed (107d) and AC Andrew (109d); Bhishaj was 6 cm taller than AC Reed and 2 cm taller than AC Andrew. Bhishaj displayed significantly ($P \leq 0.05$) weaker straw (3.3) than both AC Reed (2.9) and AC Andrew (2.5).

Table 1. Least square means for grain yield of Bhishaj compared with the check cultivars in the Western Soft White Spring Wheat Co-operative Registration Trials, 1999–2001 and 2006–2009

	Grain yield (t ha^{-1})										
Cultivar	1999	2000	2001	2006	2007	2008	2009	AB[z]	SK[z]	Mean	% of Reed
AC Reed	7.23*b*	7.14*b*	7.49*b*	6.80*c*	6.27*a*	8.00*a*	6.79*a*	7.38*b*	6.69*b*	7.14*b*	100
AC Andrew	8.20*a*	8.04*a*	7.46*b*	7.64*b*	6.70*a*	8.57*a*	7.84*a*	8.08*a*	7.22*ab*	7.79*a*	109
Bhishaj	**8.21*a***	**7.53*ab***	**8.01*a***	**8.34*a***	**6.75*a***	**8.42*a***	**7.37*a***	**8.03*a***	**7.45*a***	**7.81*a***	**109**
LSD ($P = 0.05$)[y]	0.34	0.61	0.49	0.48	0.54	0.59	1.05	0.46	0.63	0.24	
No. of tests	5	4	6	4	5	6	6	26	10	36	36

[z]Alberta test locations: Lethbridge, Vauxhall, Bow Island, and Iron Springs; Saskatchewan test locations: Outlook and Saskatoon. No yield data for the following locations: Iron Springs for year 2006 and 2007; Saskatoon for 2000; and Outlook for 1999, 2000, and 2006.
[y]Fisher's protected LSD of least square means calculated using the SAS PROC MIXED procedure (Littell et al. 2006).
a–c Means with the same letter are not significantly different.

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Bhishaj had a slightly higher kernel mass than AC Reed and AC Andrew, but exhibited good shattering resistance similar to the check cultivars (Table 2).

Bhishaj was resistant to the prevalent races of stripe rust and powdery mildew. It was moderately resistant to leaf rust and moderately susceptible to loose smut. Bhishaj was susceptible to stem rust, common bunt, and *Fusarium* head blight (Table 3). Bhishaj had improved kernel black point resistance [caused by *Alternaria alternata* (Fr.:Fr.) Keissl.] over the check cultivars (Table 3).

The milling and baking characteristics of Bhishaj were evaluated from 1999 to 2001 by the Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB. The protein content of Bhishaj (11.5%) was equal to that of AC Andrew, and slightly higher than AC Reed and AC Phil (11.1%). It had test weight similar to the mean of checks. Flour yield (75.7%) was lower than AC Phil (76.3%) and Hagberg falling number (362 s) was higher than AC Reed (352 s) and AC Phil (355 s). The amylograph peak viscosity for Bhishaj (487 BU) was lower than AC Reed (528 BU) and AC Phil (503 BU) (Table 4). Cookie spread for Bhishaj (82.3 mm) was lower than AC Reed (82.5 mm) and AC Phil (82.8 mm), but the cookie ratio (spread/height) was better than the check mean (Table 4). Overall, Bhishaj had rheological and baking properties similar to AC Reed and AC Phil.

Other Characteristics

Plant characteristics were recorded from greenhouse increases and experimental field plots grown in 2006 and 2007 at Lethbridge, AB.

Seedling Characteristics

COLEOPTILE COLOUR: Very weak anthocyanin colouration.
JUVENILE GROWTH HABIT: Intermediate.
SEEDLING LEAVES: glabrous leaf sheaths and blades of lower leaves.
TILLERING CAPACITY (AT LOW DENSITIES): Medium

Adult Plant Characteristics

GROWTH HABIT: Intermediate
FLAG LEAF: Dark green with glabrous sheath and blade. Weak auricle colouration, and auricle margins are glabrous. Flag leaf sheath has a strong waxy bloom.
FLAG LEAF ATTITUDE: drooping (recurved)
UPPER CULM INTERNODE: Straight at maturity with weak waxiness. It has a hollow stem with thin walls.
CULM COLOUR: Glabrous.

Spike Characteristics

SHAPE: Tapering
LENGTH: Medium, similar to AC Andrew, slightly longer than AC Reed
DENSITY: Medium.
ATTITUDE: Erect.
RACHIS: Dense hairiness of convex surface of apical segment.
COLOUR: White at maturity.
AWNS: Awned.

Spikelet Characteristics

GLUMES: Medium length and width; lower glume is glabrous; glume shoulders are sloping; medium shoulder width; glume beak is straight and of medium length; sparse internal glume hairs, internal imprint of lower glume is absent. Glumes are white in colour at maturity.
LEMMA: Slightly curved.

Kernel Characteristics

TYPE: Soft, white in colour.
SHAPE: Ovate to oval in shape with rounded to slightly angular cheeks.
SIZE: Medium sized with medium length and medium to wide width.
BRUSH: Large-sized with mid-long brush hairs.
EMBRYO: Med-sized oval shape; crease is mid-wide and mid-deep.
PHENOL REACTION: Light brown.

Maintenance and Distribution of Pedigreed Seed

Seed harvested from selected head rows was bulked and increased at Indian Head to form the breeder seed.

Table 2. Summary of agronomic characteristics of Bhishaj compared with the check cultivars in the Western Soft White Spring Wheat Co-operative Registration Trials, 1999–2001 and 2006–2009

Cultivar	Maturity (d)	Height (cm)	Lodging (1–9)	Shattering (1–9)	Kernel weight (g)	Kernel black point (%)[z]
AC Reed	107*a*	83*c*	2.9*b*	1.84*a*	33.3*c*	14.1*b*
AC Andrew	109*c*	87*b*	2.5*a*	1.94*a*	34.4*b*	12.4*ab*
Bhishaj	**108*b***	**89*a***	**3.3*c***	**2.00*a***	**35.7*a***	**11.2*a***
LSD ($P=0.05$)[y]	0.67	1.18	0.34	0.16	0.73	2.19
No. of tests	33	32	29	24	35	33

[z]The primary fungi associated with black point are *Alternaria alternata, Cochliobolus sativuis* and *Fusarium proliferatum.*
[y]Fisher's protected LSD of least square means was based on the checks and Bhishaj and calculated using the SAS PROC MIXED procedure (Littell et al. 2006).
a–c Means with the same letter are not significantly different.

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Table 3. Disease severities and ratings[z] of Bhishaj compared with the check cultivars in the Western Soft White Spring Wheat Co-operative Registration Trials, 2007–2009

	Stem rust[y] (% severity, rating)			Leaf rust[x] (% severity, rating)			Common bunt[w] (% infection, rating)		
Cultivar	2007	2008	2009	2007	2008	2009	2007	2008	2009
AC Reed	40 I	99 S	90 S	52 MS	35 I	30 MR	54 VS	65 VS	77 VS
AC Andrew	15 MR	10 RMR	10 RMR	47 MS	30 MR	12.5 MR	43 VS	37 MS	39 I-MS
Bhishaj	**50 MS**	**60 MS**	**90 S**	**28 MR**	**18 MR**	**2.5 R**	**48 VS**	**42 S**	**46 MS**

				Fusarium head blight[u]				
	Loose smut[v] (% infection, rating)			FHB Index (rating)			DON (ppm)	
Cultivar	2007	2008	2009	2007	2008	2009	2008	2009
AC Reed	80 S	63 MS	70 MS	43.8 S	15.3 MS	28 I	11.1	30.4
AC Andrew	60 MS	59 MS	100 S	52 S	15.3 MS	38 MS	11.3	–
Bhishaj	**34 MR**	**25 MR**	**74 MS**	**76.5 S**	**23.2 S**	**42.1 S**	**7.1**	**36.3**

	Powdery mildew (1–6)[t]			Stripe rust (1–6)[s]			Leaf spot[r]		
Cultivar	2007	2008	2009	2007	2008	2009	2007	2008	2009
AC Reed	2.6	2.1	2.2	1.5	1.6	1.0	–	6.2	28.3
AC Andrew	2.2	2.0	2.3	1.7	2.1	1.3	–	2.5	20.7
Bhishaj	**2.2**	**2.0**	**2.4**	**2.2**	**1.6**	**1.0**	**–**	**4.9**	**36.7**

[z]Disease rating class: VR = very resistant, R = resistant, RMR = resistant to moderately resistant, MR = moderately resistant; I = intermediate rating; MRMS = moderately resistant to moderately susceptible, MSS = moderately susceptible to susceptible, S = susceptible. (% incidence × % severity/100, rating).
[y]Caused by *Puccinia graminis* Pers.:Pers. f. sp. *tritici* Eriks. E. Henn. Races used include TMRTK, RKQSR, TPMKR, QTHST, RHTSK and MCCFR.
[x]Caused by *P. triticina* Eriks. Inoculum was a composite of all leaf rust disease survey collections made the previous year from Manitoba and Saskatchewan (McCallum and Seto-Goh, 2006).
[w]Caused by *Tilletia tritici* (Bjerk.) R. Wolff and *T. laevis* Kuhn in Rabenh. The inoculum used was a composite of races T-1, T-6, T-13, and T-19 of *T. tritici* and L-7 and L-16 of *T. laevis* mixed in a 1:1:1:1:2:2 ratio (vol/vol).
[v]Caused by *Ustilago tritici* (Pers.) Rostr. Races used include T2, T9, T10 and T39.
[u]Caused by *Fusarium graminearum* Schwabe (teleomorph *Gibberella zeae* (Schwein.) Petch).
[t]Powdery mildew caused by *Blumeria graminis*.
[s]Stripe rust caused by *Puccinia striiformis*. Resistance rated under conditions of natural infection; 1 = resistant, 6 = highly susceptible.
[r]Caused by main leaf spotting pathogens: P. tritici-repentis, *P. nodorum, M. graminicola*, and *C. sativus*.

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Table 4. Mean wheat and flour analytical data[z] for Bhishaj and checks cultivars in the Western Soft White Spring Wheat Co-operative Registration Trials, for 1999–2001

Cultivar	Test weight (kg hL^{-1})	Wheat protein (%)	Flour protein (%)	Protein loss (%)	Hagberg falling number (s)	Amylograph viscosity (BU)	Flour yield (%)	Flour ash (%)	Flour Agtron colour	Starch damage (mega-zyme)	Particle size index
AC Reed	82.5	11.1	10.2	0.9	352	528	75.9	0.5	74.3	3.1	69.8
AC Phil	82.6	11.1	10.1	1.0	355	503	76.3	0.5	74.5	3.0	69.3
Mean of Checks	82.5	11.1	10.1	1.0	353	516	76.1	0.5	74.4	3.1	69.6
AC Andrew	82.1	11.5	10.4	1.1	367	467	75.7	0.5	73.0	3.1	68.5
Bhishaj	**82.5**	**11.5**	**10.3**	**1.2**	**362**	**487**	**75.7**	**0.5**	**73.8**	**2.8**	**71.0**
SD	0.20	0.22	0.15	0.10	6.30	24.26	0.25	0.01	0.62	0.13	0.91

	Farinograph 54–21[y]						Alveograph				Cookie	
Cultivar	Alkaline water retention capacity	Pelshenke (min)	Absorption (%)	Doughdevelop ment time (min)	Mixing tolerance index (BU)	Stability index (min)	Length	P	W	Area	Spread (mm)	Ratio
AC Reed	61.9	23.3	54.6	1.5	170	1.2	134	24.0	53.3	8.0	82.5	8.4
AC Phil	61.6	26.7	54.6	1.4	175	1.3	143	23.3	49.3	7.6	82.8	8.6
Mean of Checks	61.7	25.0	54.6	1.5	172	1.3	138	23.7	51.3	7.8	82.6	8.5
AC Andrew	62.2	26.3	55.2	1.4	160	1.3	132	29.0	68.3	10.5	81.0	8.1
Bhishaj	**61.9**	**25.7**	**54.3**	**1.4**	**145**	**1.3**	**170**	**27.3**	**78.7**	**12.3**	**82.3**	**8.6**
SD	0.22	1.32	0.34	0.04	12.30	0.07	15.40	2.55	12.7	2.07	0.72	0.21

[z]End-use quality testing was conducted by the Grain Research Lab of the Canadian Grain Commission on composite samples from various locations.
[y]American Association of Cereal Chemists (2002).

The breeder seed of Bhishaj will be maintained by the Indian Head Research Farm, AAFC, Indian Head, Saskatchewan, Canada S0G 2K0. Multiplication and distribution of the pedigreed seed will be handled by Tony Crooymans and Sons, PO Box 57, Bow Island, Alberta, Canada T0K 0G0.

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