

# Registration of 'Busby' Barley

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## ABSTRACT

'Busby' (Reg. No. CV-343, PI 656596; CFIA Reg. No. 6540; Canadian PBR Appl. No. 08-6470) is a two-rowed, hulled, spring feed barley (*Hordeum vulgare* L.) developed at the Field Crop Development Centre (FCDC), Lacombe, AB, Canada. Busby was tested in FCDC trials as H94034003 from 2001 to 2005 and in Prairie Recommending Committee for Oat and Barley trials as TR06673 during 2006 and 2007. It was registered for production in western Canada due to its good combination of yield, agronomic performance, grain quality traits, and disease resistance. Busby is resistant to the surface-borne smuts (caused by *Ustilago* spp.) and moderately resistant to the spot form of net blotch (caused by *Pyrenophora teres* forma *maculate* Smedge). Busby has shown reactions to scald [caused by *Rhynchosporium secalis* (Oudem.) J.J. Davis] similar to the two-rowed cultivar Seebe that has proven to have durable resistance in Alberta, Canada.

'Busby' barley (*Hordeum vulgare* L.) (Reg. No. CV-343, PI 656596; CFIA Reg. No. 6540; Canadian PBR Appl. No. 08-6470) is a two-rowed, hulled, spring feed barley developed by the Field Crop Development Centre (FCDC). It was tested in Canada as H94034003 in FCDC trials from 2001 to 2005 and as TR06673 in the 2006 and 2007 Western Cooperative Two-Row Barley Registration Tests run under the auspices of the Prairie Recommending Committee for Oat and Barley (PRCOB). It was supported for registration in Canada by the PRCOB in February 2008, and registered in Canada as Busby by the Canadian Food Inspection Agency (CFIA) on 4 Feb. 2009.

Busby is derived from the cross H93089(F<sub>1</sub>)/'Seebe'. H93089 was the cross of I92121/'AC Metcalfe'. I92121 was an

introduction to FCDC from the North Dakota State University two-row barley breeding program of Jerry Franckowiak and was a selection from the cross ND7085/ND4994-15//ND7556. AC Metcalfe is a two-rowed, hulled, malting barley developed by Legge et al. (2003). Seebe is a two-rowed, hulled, feed barley developed by Helm et al. (1996) that has had excellent scald resistance under Alberta conditions and high biomass yields for silage.

## Methods

The original cross for Busby was made in 1994. The F<sub>2</sub> to F<sub>6</sub> bulks were grown in the field at Lacombe, AB, Canada, from 1995 to 1999. The bulks were modified by spreading disease-infested straw that had been collected in the previous year from scald [caused by *Rhynchosporium secalis* (Oudem.) J.J. Davis]-infested fields in the previous year. The harvested seed was screened over a gravity table to preserve the heavier seed with the speculation that those genotypes within the bulk with better resistance would produce more and heavier seed. Two hundred heads were selected from the 1999 F<sub>6</sub> bulk and grown out as individual F<sub>7</sub> head rows at Lacombe in 2000. The headrow from which Busby was developed was selected from this population. In 2001 this line was designated as H94034003 and tested in a nonreplicated yield plot at Lacombe.

In 2001 200 heads were selected from the yield test plot, and these formed the basis of the purification increases that were run for removal of variants and to compile detailed descriptions. Each year 200 heads were selected to type, threshed, and grown out as a bulk increase plot in the next year until 2004, when 200 heads were grown out as individual headrows. Heads were picked from each row to provide the source for the Prebreeder headrow nursery that was grown in 2005. All off-type rows were discarded. One hundred ninety-eight F<sub>13</sub> Breeder headrows and plots were grown out in 2006, but the plots were lost due to hail. The

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**Abbreviations:** AAFC, Agriculture and Agri-Food Canada; CDC, Crop Development Centre; CFIA, Canadian Food Inspection Agency; CIMMYT, International Wheat and Maize Improvement Centre; FCDC, Field Crop Development Centre; FHB, Fusarium head blight; ICARDA, International Centre for Agricultural Research in the Dry Areas; PRCOB, Prairie Recommending Committee for Oat and Barley; U of S, University of Saskatchewan.

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rows were harvested to be grown in 2007. One hundred ninety-seven F<sub>14</sub> rows and plots were harvested and bulked to form the first Breeder seed grown in 2008.

In 2002 and 2003, H94034003 was tested in replicated multisite field tests throughout Alberta. In 2004 and 2005, H94034003 was tested in yield tests across western Canada. Yield, test weight, kernel weight, percentage plump, days to anthesis, days to maturity, height, and lodging of this line were evaluated in these tests. Data from FCDC trials were analyzed using SAS software (SAS Institute, Cary, NC). Field trial data was analyzed using Proc ANOVA of SAS and kept as valid if test coefficients of variation for yield were less than 15%. Lodging data were assessed at most sites; because significant differential lodging was only noted at five locations, data were entered into the data set for these locations. These data were stored in the Field Crop Dataminer, a customized system for data storage and analyses based on SAS software, so that data could be reanalyzed over locations and years.

H94034004 was sent to Agriculture and Agri-Food Canada (AAFC)–Brandon, MB, for field assessment of Fusarium head blight (FHB, predominantly caused by *Fusarium graminearum* Schwabe [telemorph *Gibberella zeae* (Schwein.) Petch]) using corn residue inoculum at 5 g row<sup>-1</sup>, net blotch (caused by *Pyrenophora* spp.), and spot blotch [caused by *Cochliobolus sativus* (Ito & Kuribayashi) Drechs. ex Dastur] in hill plots with inoculated spreader rows. H94034004 was sent to University of Saskatchewan –CDC-Saskatoon for field assessment of spot blotch and net blotch. At Saskatoon, spot blotch infested straw was spread throughout the hill plot nursery. Net blotch was allowed to develop naturally. At AAFC–Lacombe, scald and smut (caused by *Ustilago* spp.) resistance were assessed. Scald assessments were done in the AAFC–Lacombe inoculated field nursery. Smut assessment was done by field inoculation using the air-brush technique developed by Wolfe et al. (1993) with grow-out of inoculated heads in the growth rooms during the following winter. At the International Centre for Agricultural Research in the Dry Areas (ICARDA)–The International Wheat and Maize Improvement Centre (CIMMYT), Mexico, H94034003 was assessed in field nurseries for scald, leaf rust (caused by *Puccinia hordei* G. Otth.), stripe rust (caused by *P. striiformis* Westend, f. sp. *hordei* Eriks.), and FHB. Scald assessment was done at the Toluca site where inoculation was done by spore suspension. Leaf rust was assessed at the Ciudad Obregón site where inoculation was done by spore suspension application to spreader rows. Stripe rust was assessed at the Toluca, Mexico, site and was dependent on natural inoculation. Fusarium was assessed until 2006 at the Toluca site and thereafter at the El Batán, Mexico, site by inoculation.

Using near infra-red spectroscopy 65000 (FOSS NIRSystems, Inc. Laurel, MD) and calibrations developed by Helm (2006), Helm et al. (2000, 2003), and Temelli and Helm (1999), H94034003 was assessed for grain quality traits of protein, protein digestibility, energy digestibility, digestible energy, lysine, starch, beta-glucan, pentosan, lipid, total fiber, soluble fiber, grain color, pearl color, and pearl rating.

H94034003 was tested for water use efficiency based on grain and biomass production per unit of water applied.

Assessments were made by growing plants in pots under a rain-out shelter during the summer time with limited application of water. The experimental design was a three replicate randomized complete block. Five plants of the line were grown per pot, and each pot was considered a plot. At maturity, plants were harvested, dried, and weighed for biomass measurement and then threshed for grain yield. Data were analyzed using Proc GLM of SAS. Assessments were made on a yearly basis from 2004 to 2008; however, the 2005 and 2006 data were discarded due to damage to the trials.

For determination of silage potential, dry matter whole-plant samples were harvested at the soft-dough stage using a small plot silage harvester; subsamples were dried and biomass yield and quality were determined. Protein, acid detergent fiber, and neutral detergent fiber traits were measured by wet chemistry at Parkland Laboratories, Red Deer, AB, Canada. Biomass yield assessments were made from 2004 to 2008 from trials grown at Lacombe. Plot layout was a three replicate randomized complete block.

On the basis of these data, H94034003 was entered into the Western Cooperative Two-Row Barley Registration Tests as TR06673 (see Prairie Recommending Committee for Oat and Barley, 2008, for the protocols for the running of the PRCOB cooperative trials). Check cultivars for the tests were established on a yearly basis by the PRCOB. Statistical analyses of these trials were done at the discretion of the test coordinator or evaluation team. Least significant differences at  $\alpha = 0.05$  were determined by the test coordinator based on their software or calculated based on standard errors of the means provided with the trial results.

## Characteristics

### Unique Characteristics of Busby

In the multisite tests run by FCDC, Busby was selected on the basis of its multiyear scald resistance similar to its parent Seebe (Table 1). Since its release in 1992, Seebe has proven to have durable resistance under conditions in

**Table 1. Reactions of 'Busby', 'Harrington', and 'Seebe' barley in multiyear inoculated field tests run at Edmonton and Lacombe, AB, Canada.**

Year	Location	Scald rating		
		Harrington	Seebe	Busby
		0–9 <sup>†</sup>		
2003	Lacombe	2.5	0	0
	Edmonton	8	1	1.5
2004	Lacombe	7.5	3.5	2
	Edmonton	7	0	0
2005	Lacombe	7.5	1	0
	Edmonton	5	1	0
2006	Lacombe	na <sup>‡</sup>	5.5	2.5
	Edmonton	na	0	1
2007	Lacombe	na	4	3
	Edmonton	na	2	0

<sup>†</sup>0 = resistant, 9 = susceptible.

<sup>‡</sup>na, data not available.

Alberta, and incorporation of this resistance into a superior genotype was the intent of the cross H94034. In the 3 yr of FCDC yield trials where Seebe was included as a check cultivar, Busby showed a yield advantage of 10% over Seebe and 6% over AC Metcalfe (Table 2). Busby reached anthesis and maturity approximately 4 d earlier than Seebe, and while it reached anthesis 2 d earlier than AC Metcalfe, Busby reached maturity at the same time. Kernel weight of Busby was higher than those of Seebe and AC Metcalfe, and test weight of Busby was higher than that of Seebe. Busby was similar in height and lodging resistance to Seebe. Busby was evaluated in 5 yr of testing for biomass dry matter yields at the soft-dough stage (timed to simulate harvest for silage production), and biomass yields were about the same as Seebe.

In the PRCOB Western Cooperative Two-Row Barley Registration Tests in 2006 and 2007, Busby had higher yields than the malting checks 'Harrington' (Harvey and Rossnagel, 1984), AC Metcalfe, 'CDC Kendall' (CFIA, 2009), and

'CDC Copeland' (CFIA, 2009), with yields 108% of AC Metcalfe in these 2 yr (Table 3); however, its yields were only 94% of the feed check 'Xena' (CFIA, 2009). Days to heading for Busby were earlier than all check cultivars. Maturity of Busby was similar to the malting checks, being slightly earlier than the feed check Xena. While taller than the check cultivars, Busby's lodging score (1–9 scale) was similar to Xena. Average test weight for Busby was 66.1 kg hL<sup>-1</sup> and was very similar across the 2 yr of testing to the feed check Xena. With an average kernel weight of 48.7 mg, Busby had a heavier kernel than the malting check cultivars but was similar to that of Xena. Busby had an average kernel plumpness of 90%, similar to that for Xena.

The Disease Evaluation Team of the PRCOB rated Busby as resistant to the surface-borne smuts (caused by *Ustilago* spp.) but susceptible to true loose smut [caused by *U. nuda* (Jensen) Kellerman & Swingle] (Table 4). Busby was rated as moderately resistant to the spot form of net blotch but moderately susceptible to the net form (*Pyrenophora teres*

**Table 2. Yield and agronomic traits of 'Busby', 'AC Metcalfe', and 'Seebe' barley in Field Crop Development Centre tests run in 2003, 2004, and 2007 at Brandon, MB (2004 only), Calmar, Lacombe [(high fertility (2007 only), low fertility, and late seeding (2004 and 2007 only)], Lethbridge (irrigated and dryland, 2003 and 2004 only), Morrin (2007 only), Olds, Stettler (2004 only), and Trochu (2007 lost due to hail), AB, and Saskatoon, SK (2004 only), Canada.**

Entry	Grain yield kg ha <sup>-1</sup>	Anthesis —— d ——	Maturity	Kernel weight mg	Test weight kg hL <sup>-1</sup>	% Plump % > 2.44 mm	Height cm	Lodging 0–9 <sup>†</sup>	Biomass dry matter yield <sup>†</sup> kg ha <sup>-1</sup>
AC Metcalfe	6617	56.4	99	45.2	65.8	86.2	86.3	3.4	14,465
Seebe	6474	58.9	103	47.9	65.0	86.5	91.2	1.7	14,086
Busby	6990	54.5	99	50.2	66.6	88.3	91.9	2.2	13,783
LSD <sub>0.05</sub>	83	0.6	1	0.9	0.9	2.6	1.3	1.8 NS <sup>§</sup>	956 NS
No. station years	23	20	17	22	22	18	23	5	5

<sup>†</sup>Data from 2004 to 2008 from tests run at Lacombe, AB.

<sup>†</sup>0 = not lodged, 9 = completely lodged.

<sup>§</sup>NS, not significant.

**Table 3. Grain yield and agronomic traits of 'Busby' barley and the check cultivars from the 2006 and 2007 Western Cooperative Two-Row Barley Registration Tests.**

Entry	Grain yield kg ha <sup>-1</sup>	Heading —— d ——	Maturity	Height cm	Lodging Score 1–9 <sup>†</sup>	Test weight kg hL <sup>-1</sup>	Kernel weight mg	% Plump % > 2.44 mm
<b>2006</b>								
Harrington	5065	58.0	86.1	81.0	6.0	64.5	42.6	88.0
Xena	6266	57.8	87.5	83.6	4.8	67.0	49.8	93.4
AC Metcalfe	5334	58.4	86.9	83.1	5.7	66.2	44.7	89.9
CDC Kendall	5290	59.2	86.0	80.8	6.8	65.4	43.4	92.7
Busby	5872	55.5	85.9	90.6	5.2	66.7	49.3	92.0
LSD <sub>0.05</sub>	147	0.4	0.5	1.4	1.0	0.7	1.3	2.8
No. station years	16	13	13	14	2	13	13	10
<b>2007</b>								
CDC Copeland	5048	59.0	90.0	87.0	4.5	63.3	43.8	88.0
Xena	5629	56.6	90.3	85.6	3.8	65.8	47.2	87.9
AC Metcalfe	5071	56.6	89.2	85.9	4.2	64.7	42.7	86.8
Busby	5315	55.0	89.4	92.5	3.7	65.5	48.1	88.6
LSD <sub>0.05</sub>	159	0.3	0.58	1.5	1.6	0.7	1.3	2.8
No. station years	15	11	13	14	2	12	12	11

<sup>†</sup>1 = not lodged, 9 = totally lodged.

Table 4. Reaction to diseases for 'Busby' barley and the check cultivars from the 2006 (06) and 2007 (07) Western Cooperative Two-Row Barley Registration Tests.†

Entry	Scald (adult)		Scald (seed)‡		Spot blotch		Winn.- spot blotch 1903§		Stem rust MCC (seed)§		Net blotch¶		Sept. 1998‡§		Smut		Covered smut‡		FHB		DON		CRR																				
	Lac.	Edmon.	Winn.	Melfort	Sask.	Brand.	102	858	857	Melfort	U. nuda	U. hordei	U. nigra	Sask.	Brand.	Lac.	06	07	06	07	06	07	06	07	06	07																	
Harrington	6.5	x <sup>§§</sup>	1.5	x	4.5	x	7.5	x	7	x	3-2	x	10	x	10	x	9	x	7.5	x	S	x	29	x	10	x	22.5	x	S	x	2.3	x	5.9	x	89	x							
CDC Copeland	x	9	x	3	x	S	x	5	x	5.5	x	4.5	x	6	x	0;	x	6	x	9	x	5	x	2	x	x	x	94	x	0.5	x	0	x	MR	x	1.8	x	1.9	x	96			
Xena	7	8.5	2.5	2	S	S	5	4.5	5	4.5	7	5	6	7	0;1	0;	10	9	10	10	3	5	2	1	S	x	81	89	3	0	40	0	S	S	1.3	2.2	3.7	1.7	89	57.3			
AC Metcalfe	6	8.5	0.5	2	S	S	3.5	3.5	4.5	3.5	5.5	5	6	6	0;1	0;	9	9	10	9	5	5	4.5	3.5	S	x	0	0	3	0	7.5	0	R	R	2.3	2.3	5.6	5.9	89	80			
CDC Kendall	4	x	2	x	S	x	4	x	4.8	x	4	x	6.5	x	6	x	3-2	x	5	x	9	x	3	x	1.5	x	S	x	81	x	3.5	x	26.5	x	MR	x	2.5	x	5.4	x	87	x	
Busby	1.5	5	0	0	S	MS	4	4	4	4	4	4	4	4	5	7	0;	0;	1	6	9	10	2	3	1.5	1.5	S	x	88	41	0	0	0	0	0	0	1	2	3.3	4.4	4.8	92	93.3

†Lac., Lacombe; Edmon., Edmonton; seed., seedling; Winn., Winnipeg; Sask., Saskatoon; Brand., Brandon; Sept., Septoria; FHB, Fusarium head blight; DON, deoxynivalenol; CRR, common root rot; U., *Ustilago*.

‡S = susceptible, MS = moderately susceptible, I = intermediate resistance, MR = moderate resistance, R = resistant.

§Alphabetic or numeric value indicates a race of the pathogen.

¶Net blotch races 102 and 858 are the net form; race 857 is the spot form.

‡‡Rating of 0-9 or 1-9, where 9 = susceptible.

‡‡‡Rating of 0-5, where 5 = susceptible.

§§§"x" indicates data were not available.

forma *teres*). Busby was rated as moderately susceptible to spot blotch. Busby was rated as moderately resistant-moderately susceptible to FHB (scab), scald, and stem rust (caused by *Puccinia graminis* Pers. f. sp. *tritici* Erikss. and Henn.). Busby was rated as susceptible to common root rot and septoria or speckled leaf blotch (caused by *Septoria passerinii* Sacc.). The moderately susceptible rating for scald resistance was due to Busby's seedling reaction of susceptible to *R. secalis* isolate 1493, similar to Seebe's seedling reaction.

The Barley Quality Evaluation Team of the PRCOB rated Busby as having similar test weight, kernel weight, and plumpness to the check Xena (Table 3). In FCDC tests where AC Metcalfe, Seebe, and Xena were grown with Busby, Busby had higher protein and digestible energy than Xena and lower dietary fiber (Table 5). Grain quality traits of protein, lysine, digestible energy, starch, soluble fiber, pentosans, beta-glucans, and lipids for Busby were similar to AC Metcalfe. Protein digestibility for Busby was lower than for AC Metcalfe but higher than for Seebe, while the opposite was true for total fiber.

### Morphological Description of Busby

As a seedling, Busby has a semi-erect growth habit with a green coleoptile of intermediate length. The leaf sheath and blade of Busby are glabrous and green in color at both the seedling and booting stages. By the booting stage, the leaf has a slight waxy bloom. The flag leaf of Busby is of medium length and width and has an intermediate attitude with slight waxiness. The auricles of Busby are purple colored and glabrous. After heading, the stem of Busby is exerted 9 cm. The stem is of medium thickness, with slight waxiness, and medium green color. The collar is platform shaped, and the culm neck is slightly curved. The spike is parallel or strap shaped, dense, of medium length, with a horizontal attitude, and slight waxiness. The sterile spikelets of Busby are strongly divergent. The first rachis internode is of medium length with a slight curve. The rachis margin is strongly pubescent. The glumes are medium long with a band of medium-length glume hairs. The glume awns are equal in length to the glume and rough. The glume awn tip color is green. The lemma awns are longer than the spike and rough. The lemma awn has a green tip. The lemma has a few barbs on its lateral veins. The lemma nerve color is green. The kernel has a mid-long rachilla with short rachilla hairs. The kernel has a colorless (yellow/white) aleurone and is of medium length and width with an incomplete horse-shoe basal marking. The lodicules are clasping. Busby has fair lodging resistance (Tables 2 and 3) and good drought tolerance as measured by water use efficiency (Table 6). It has good tolerance to neck and straw breakage (visual assessment).

### Availability

Breeder seed of Busby will be maintained by the Field Crop Development Centre, Lacombe, AB, Canada.

**Table 5. Feed and food quality traits as evaluated using near infra-red spectroscopy for 'Busby', 'AC Metcalfe', 'Seebe', and 'Xena' barley from Field Crop Development Centre tests run in 2004 and 2007 at Calmar, Lacombe (high fertility, low fertility, late seeding), Olds, Trochu (2004 only), and Morrin (2007 only), AB, Canada.**

Entry	Mean (12 station-yr)									
	Grain protein	Protein digestibility	Lysine	Digestible energy	Starch	Total fiber	Soluble fiber	Pentosan	Beta-glucan	Lipid
	%			kcal kg <sup>-1</sup>	%					
AC Metcalfe	11.7	76.0	0.62	3122	61.7	18.3	4.03	5.51	3.58	2.78
Seebe	13.3	72.0	0.65	3128	61.3	19.1	4.47	5.26	3.88	2.78
Xena	11.3	74.9	0.58	3063	60.6	19.6	4.33	5.55	3.31	2.76
Busby	11.8	73.9	0.62	3106	61.6	18.6	4.14	5.48	3.46	2.71
LSD <sub>0.05</sub>	0.4	1.4	0.17	20	0.5	0.3	0.20	0.07	0.12	0.08 NS <sup>†</sup>

<sup>†</sup>NS, not significant.

Application for variety protection has been made for Busby. Before termination of plant breeder's rights or 20 years from deposit in the National Plant Germplasm System, all seed requests should be sent to the corresponding author. Seed deposited in the National Plant Germplasm System will be available for research purposes after plant breeder's rights are terminated or 20 years. Where this cultivar is used as a parent in the development of new cultivars, it is requested that recognition be made of its use. Commercial seed distribution rights of Busby were granted to Mastin Seeds, RR 1 Sundre, AB, Canada, T0M 1X0; Tel: (403) 556-2609; Fax: (403) 507-2609; email: mastinseeds@yahoo.com.

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**Table 6. Water use efficiency (WUE) of 'Busby' barley compared to 'AC Metcalfe' and 'Xena'; based on grain and biomass yields when grown in rain-out shelters with limited water supply.**

Year of testing	AC Metcalfe	Busby	Xena	LSD <sub>0.05</sub>
	WUE <sub>Grain</sub>			
	kg m <sup>-2</sup> mm <sup>-1</sup>			
2008	13.47	14.90	14.28	3.39
2007	10.13	13.24	9.59	5.37
2004	7.32	11.88	6.77	5.08
	WUE <sub>Biomass</sub>			
	kg m <sup>-2</sup> mm <sup>-1</sup>			
2008	46.7	43.5	46.8	5.55
2007	35.9	36.8	29.5	7.51
2004	38.7	45.5	43.1	5.64

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