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Registration of 'Buck' Naked Barley

Brigid Meints, Ann Corey, Chris Evans, Tanya Filichkin, Scott Fisk, Laura Helgerson, Andrew S. Ross, and Patrick M. Hayes*

Abstract

'Buck' (Reg. No. CV-363, PI 682744) is a naked (hull-less), six-row barley (*Hordeum vulgare* L.) cultivar with winter growth habit. The cultivar was released by the Oregon Agricultural Experiment Station in 2015. The name *Buck* was chosen because the cultivar is naked. Prior to being named, Buck was tested under the experimental designation 09OR-86. In high-rainfall environments, it had a yield advantage over the naked check and had an excellent test weight. When grain yield was adjusted for the weight of hulls, Buck was competitive with all checks. Buck is resistant to barley stripe rust and moderately resistant to leaf rust. Buck was developed as a whole-grain human food barley. However, multi-use (e.g., food, malting, and feed) is an option. Feeding data are not available. Malting quality data indicate that Buck has higher malt extract than current covered (hulled) malting cultivars. Buck is the first naked winter cultivar to be released with adaptation to the US Pacific Northwest.

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5585 Guilford Rd., Madison, WI 53711 USA
*Corresponding author (patrick.m.hayes@oregonstate.edu)

'Buck' (Reg. No. CV-363, PI 682744) is a naked, six-row barley (*Hordeum vulgare* L.) cultivar with winter growth habit. The cultivar was released by the Oregon Agricultural Experiment Station in 2015. The name *Buck* was chosen because the cultivar does not have an adhering hull. *Naked* is the preferred term for this trait, although the term *hull-less* is also used. Prior to being named, Buck was tested under the experimental designation 09OR-86. In high-rainfall environments, it had a yield advantage over the naked check and had an excellent test weight. Buck is resistant to barley stripe rust (incited by *Puccinia striiformis* f. sp. *hordei*) and moderately resistant to leaf rust (incited by *P. hordei* Otth). The primary end use of Buck grain is as food for human consumption, but feed use is also possible. Buck is also suitable for malt, beer, and whiskey production under specialized conditions, given its potential to have high malt extract percentage. Naked barley absorbs water more rapidly that covered barley, which can reduce malting time, energy, and water needs (Agu et al., 2009). The hull accounts for approximately 11 to 13% of the grain weight but does not contribute to starch content; therefore, naked barleys have a much higher potential alcohol content than covered barleys (Agu et al., 2009). Additionally, with advances in brewing technology and mash filters, many brewers no longer require the hull to serve as a filter. In the increasingly competitive craft malt and beer movement, brewers are looking for unique ingredients that can lead to a novel product that will set them apart.

Buck was derived from a cross made in 2003 between 'Strider' and 'Doyce'. Strider is a six-row, covered feed barley released by the Oregon Agricultural Experiment Station in 1997. Doyce is a six-row, naked feed barley with winter growth habit, released by the Virginia Agricultural Experiment Station (Brooks et al., 2005).

Buck was tested as 09OR-86 in the Oregon Food Barley (OFOOD) trial and Winter Barley Germplasm Nursery (WBGN). The OFOOD trial was grown for 2 yr (2011–2012 and 2012–2013) at eight locations, with five of the locations replicated over the 2 yr for a total of 13 growing environments. The WBGN was grown for 3 yr (2013–2014, 2014–2015, and

B. Meints, Dep. of Crop and Soil Sciences, Northwestern Washington Research and Extension Center, Washington State Univ., Mount Vernon, WA 98273; A. Corey, T. Filichkin, S. Fisk, L. Helgerson, A.S. Ross, and P.M. Hayes, Dep. of Crop and Soil Science, Oregon State Univ., Corvallis, OR 97331; C. Evans, USDA-ARS, Aberdeen, ID 83210.

Abbreviations: CCRU, Cereal Crops Research Unit; OFOOD, Oregon Food Barley; WBGN, Winter Barley Germplasm Nursery.

2015–2016) at seven locations, with four of the locations replicated over the 3 yr for a total of 16 growing environments.

In the OFOOD trial, Buck is compared with #STRKR, a blend of three pure sister lines, recently released as a germplasm by Oregon State University (Meints et al., 2015). Although comparable in many ways, Buck shows some key advantages over #STRKR, including much improved threshability (data not shown), which eliminates the need for processors to pearl or dehull the grain before marketing. These processes can remove part of the bran and germ in addition to the hull, resulting in a product that can no longer be sold as a "whole grain" (Jones, 2010). Additionally, as a single pure line, certified classes of seed are available for Buck but not for #STRKR (a germplasm). As a pure line, Buck may be more tractable for malting than #STRKR, which varies in germination time between the three sister lines and would result in uneven modification. Buck is the first naked winter cultivar with adaptation to the US Pacific Northwest to be released.

Methods

Generation Development and Line Selection

The cross between Strider and Doyce was made in 2003. Selections were made using a modified bulk-pedigree method. All generations from the F_1 through F_4 were grown under fall-planted conditions at the Oregon State University Hyslop Research Farm near Corvallis, OR. The F_2 populations were planted in bulk, from which individual heads were selected, threshed, bulked, and planted as an F_3 population. From the F_3 population, heads were selected and planted in F_4 head rows. Selected rows from the F_4 head rows were harvested in bulk and advanced to a preliminary yield trial. Selections were subsequently grown in replicated, multi-environment yield trials in Oregon for multiple years. Starting in fall 2011, 09OR-86 was planted in the OFOOD trial for 2 yr across eight locations in the Pacific Northwest for a total of 13 environments (Corvallis, Hermiston, Pendleton, OR, in 2011–2012 and 2012–2013; Lewis-Brown, OR, in 2011–2012; Aberdeen, ID, in 2011–2012 and 2012–2013; Parma, ID, in 2011–2012; Pullman, WA, in 2011–2012 and 2012–2013; Mount Vernon, WA, in 2011–2012). Starting in fall 2013, 09OR-86 was planted in the WBGN for 3 yr across seven locations across the western United States for a total of sixteen environments (Corvallis, OR, in 2013–2014, 2014–2015, and 2015–2016; Mount Vernon, WA, in 2013–2014, 2014–2015, and 2015–2016; Aberdeen and Rupert, ID, in 2013–2014, 2014–2015, and 2015–2016; Oakley, ID, in 2015–2016; St. Paul, MN, in 2013–2014; and Logan, UT, in 2014–2015 and 2015–2016).

Seed Increase, Selection, and Genotyping

Six hundred heads were selected from strips of 09OR-86 at the Oregon State University Hyslop Farm near Corvallis in summer 2013 and planted for head row purification and increase in fall 2013 at the Oregon State University Lewis-Brown Farm near Corvallis. In 2015, Washington State Crop Improvement (http://washingtoncrop.com/) increased Buck for foundation seed. Seed from a single head selection of Buck was used to grow a single plant for DNA extraction and genotyping using single nucleotide polymorphisms under the auspices of the USDA National Institute of Food and Agriculture Triticeae Coordinated Agricultural Project (http://www.triticeaecap.org/). These genotype data are available at the T3 database (USDA National Institute of Food and Agriculture, 2017). In the T3 database, Buck can be found by searching for "09OR-86."

Quality Analysis

Grain β-glucan percentage was measured with the Megazyme enzymatic assay procedure (Megazyme International Ireland) (AACC Method 32-23.01; AACC International, 1999), using the modified protocol established by Hu and Burton (2008). Grain protein percentage was measured with near infrared reflectance spectroscopy (Infratec 1241 Grain Analyzer, Foss). Kernel hardness was measured on a SKCS 4100 (Perten Instruments) single-kernel characterization system. Solvent retention capacity was measured using AACC Approved Method 56-11.02 (AACC International, 2009). Micro-malting was performed at the USDA-ARS Cereal Crops Research Unit (CCRU) in Madison, WI, using a Joe White Malting unit. Malt analyses were performed as described by Mohammadi et al. (2015).

Statistical Analysis

All statistical analyses were conducted with SAS software, SAS version 9.4 for Windows (SAS Institute, 2013). Thirteen environments from the OFOOD trial were included in the analysis of agronomic and food quality traits, and 16 environments for the WBGN were included in the analysis of agronomic traits, although not all traits were measured at all locations. Buck was compared to a recently released naked check, #STRKR (tested as Streaker) (Meints et al., 2015), and covered checks 'Maja' and 'Alba' (Graebner et al., 2015) in the OFOOD trial. Buck was compared to Maja and Alba in the WBGN. Plot size, seeding rate, nutrient management, weed control, and irrigation (if applied) were in accordance with sound agronomic practice at each location. Entries were replicated either two, three, or four times at each location. Analysis of trial data were based on the trial means and were conducted across locations. Mean separation tests were based on LSD ($P = 0.05$).

Characteristics

Botanical Description

Buck is a naked six-row barley cultivar in which all plants have semi-compact spikes, rough awns, and long rachilla hairs. Buck has winter growth habit; it requires vernalization and has sufficient low temperature tolerance for production in the areas tested. Aleurone color is primarily white, although some blue kernels may be present.

Agronomic Performance

Oregon Food Barley Trial

Across 13 environments, Buck was lower yielding than Alba and Maja and higher yielding than #STRKR, but the differences were not significant. Reduced yield is expected from naked cultivars when compared to covered cultivars due to the weight of the hull, which can account for 11 to 13% of the weight of the kernel (Rey et al., 2009). When the covered checks are adjusted to a rate of 12% lower yield to account for

the weight of the hull, Buck outyields both covered checks (although the difference is not significant). Buck was significantly taller than #STRKR and Maja. Grain from Buck had significantly heavier test weight than Alba, Maja, and #STRKR across all growing conditions. Buck flowered significantly later than Maja and #STRKR under all growing conditions (Table 1). The full data OFOOD set was divided into dryland, high-rainfall, and irrigated environments because these classifications are relevant descriptors of environments where Buck could be grown. In these separate environment descriptions, no adjustment of hull weight was made for comparison of grain yield or test weight.

Pendleton, OR, and Pullman, WA, have respective annual rainfall averages of 420 and 540 mm yr^{-1} (Western Regional Climate Center, 2017) with no supplemental irrigation applied and are therefore classified as dryland locations. Buck yielded significantly less than Alba but was similar to Maja and #STRKR (Table 2). Corvallis, OR, Lewis-Brown, OR, and Mount Vernon, WA, have average rainfall greater than 800 mm yr^{-1} (Western Regional Climate Center, 2017) and are therefore classified as high-rainfall locations. Under these conditions, Buck yielded significantly less than Alba (Table 3). In Hermiston, OR, and Aberdeen and Parma, ID, the average annual rainfall is below 400 mm yr^{-1} and supplemental irrigation is applied in accordance with local practice. Under irrigated conditions, there were no significant differences in yield between Buck and the checks (Table 4).

Table 1. Agronomic performance and food quality of barley cultivar Buck and check cultivars across 13 environments in the OFOOD trial (4 high rainfall, 4 dryland, 5 irrigated).†

Cultivar	Agronomic traits				Food quality traits			
	Yield	Heading date	Plant height	Test weight	β-glucan	Protein	Solvent retention capacity (water)	Kernel hardness
	kg ha^{-1}	d from 1 Jan.	cm	kg hL^{-1}	% (w/w)	%	%	SKCS units‡
#STRKR	6238	134.1	90.7	74.1	4.1	12.2	100.8	46.1
Alba	7299	142.0	99.4	65.9	4.3	11.0	107.4	69.1
Maja	6746	136.3	90.6	65.0	3.9	11.2	100.5	52.4
Buck	6485	142.6	95.4	77.7	4.0	10.6	98.5	42.6
No. of environments	9	7	13	9	11	11	10	13
LSD (0.05)	1056	3.9	4.4	2.6	0.3	0.6	5.1	4.9

† Corvallis, OR (2011–2012 and 2012–2013); Hermiston, OR (2011–2012 and 2012–2013); Lewis-Brown, OR (2011–2012); Pendleton, OR (2011–2012 and 2012–2013); Mount Vernon, WA (2011–2012); Pullman, WA (2011–2012 and 2012–2013); Aberdeen, ID (2011–2012 and 2012–2013); and Parma, ID (2011–2012).

‡ SKCS, single-kernel characterization system.

Table 2. Agronomic performance and food quality of barley cultivar Buck and check cultivars across four dryland environments in the Oregon Food Barley trial.†

Cultivar	Agronomic traits				Food quality traits			
	Yield	Heading date	Plant height	Test weight	β-glucan	Protein	Solvent retention capacity (water)	Kernel hardness
	kg ha^{-1}	d from 1 Jan.	cm	kg hL^{-1}	% (w/w)	%	%	SKCS units‡
#STRKR	5860	144.0	89.7	74.3	4.3	14.2	108.2	45.5
Alba	7512	147.0	95.6	66.7	4.3	12.2	111.6	70.4
Maja	6023	146.0	87.0	68.3	4.0	12.7	99.7	48.9
Buck	5973	152.0	90.3	78.0	4.2	12.1	103.4	42.0
No. of environments	3	2	4	3	4	4	4	4
LSD (0.05)	844	13.5	9.2	2.0	0.2	1.2	9.1	6.4

† Pendleton, OR (2011–2012 and 2012–2013), and Pullman, WA (2011–2012 and 2012–2013).

‡ SKCS, single-kernel characterization system.

Table 3. Agronomic performance and food quality of barley cultivar Buck and check cultivars across four high-rainfall environments in the Oregon Food Barley trial.†

Cultivar	Agronomic traits				Food quality traits			
	Yield	Heading date	Plant height	Test weight	β-glucan	Protein	Solvent retention capacity (water)	Kernel hardness
	kg ha^{-1}	d from 1 Jan.	cm	kg hL^{-1}	% (w/w)	%	%	SKCS units‡
#STRKR	4635	123.3	92.8	76.0	4.4	11.8	94.2	50.6
Alba	8243	136.3	111.0	67.0	4.3	10.0	104.6	74.9
Maja	4927	125.3	96.2	60.5	3.5	10.6	100.9	56.9
Buck	5704	135.3	101.5	80.5	4.4	10.3	94.5	50.0
No. of environments	2	3	4	2	2	2	2	4
LSD (0.05)	1360	4.1	5.7	12.6	1.2	3.0	12.4	9.6

† Corvallis, OR (2011–2012 and 2012–2013); Lewis-Brown, OR (2011–2012); and Mount Vernon, WA (2011–2012).

‡ SKCS, single-kernel characterization system.

Winter Barley Germplasm Nursery

Across 16 environments, Buck was significantly lower yielding than Alba and Maja. When the covered checks were adjusted to a rate of 12% lower yield to account for the weight of the hull, the differences were no longer significant. Buck was significantly later to flower and significantly taller than Maja. Buck had a significantly heavier test weight than Alba and Maja. Across all environments, Buck lodged significantly more than Alba or Maja but had significantly less brackling than Maja (Table 5). The full data WBGN data set was divided into high-rainfall and irrigated environments because these classifications are relevant descriptors of environments where Buck could be grown. In these separate environment descriptions, no adjustment of hull weight was made for comparison of grain yield or test weight.

As in the OFOOD trial, Corvallis and Mount Vernon are classified as high-rainfall regions, as is St. Paul, MN. Under these conditions, Buck yielded significantly less than Alba. Buck was significantly later to flower and significantly taller than Maja. Buck had a significantly heavier test weight than Alba and Maja. Under the high-rainfall conditions, Buck lodged significantly more than Alba and brackled significantly less than Maja (Table 6).

Aberdeen, Rupert, and Oakley, ID, receive less than 400 mm yr^{-1} average precipitation; therefore, supplemental irrigation is applied. Although Logan, UT, receives slightly more precipitation at 420 mm yr^{-1} average rainfall (Western Regional Climate Center, 2017), supplemental irrigation is also applied. Under these conditions, Buck had a significantly lower yield than Maja and Alba. Buck flowered significantly later than Alba and Maja and was significantly taller than Maja. Buck had a significantly heavier test weight than either Maja or Alba. Buck lodged significantly more frequently than Maja, and brackling was not measured under irrigated conditions (Table 7).

Disease Resistance

Disease was measured all years for both trials under high-rainfall conditions: no diseases were observed at the dryland or irrigated locations. Barley stripe rust, leaf rust, and scald (incited by *Rhynchosporium commune*) severity were measured based on the method described by James (1971). Buck showed resistance to barley stripe rust at all high-rainfall locations in both trials. In both trials, Buck was significantly more susceptible to scald than Alba, and Buck was significantly less susceptible to scald than was #STRKR in the OFOOD trial (Tables 8 and 9). Seedling

Table 4. Agronomic performance and food quality of barley cultivar Buck and check cultivars across five irrigated environments in the Oregon Food Barley trial.†

Cultivar	Agronomic traits				Food quality traits			
	Yield	Heading date	Plant height	Test weight	β-glucan	Protein	Solvent retention capacity (water)	Kernel hardness
	kg ha^{-1}	d from 1 Jan.	cm	kg hL^{-1}	% (w/w)	%	%	SKCS units‡
#STRKR	7324	140.5	89.9	73.0	3.9	10.8	96.8	43.0
Alba	6667	145.5	93.0	64.8	4.3	10.4	104.5	63.4
Maja	8199	143.0	89.0	64.8	3.9	10.1	101.1	51.7
Buck	7261	144.0	94.6	76.0	3.6	9.6	95.7	37.2
No. of environments	4	2	5	4	5	5	4	5
LSD (0.05)	1285	1.8	7.3	3.0	0.5	0.9	8.6	10.9

† Hermiston, OR (2011–2012 and 2012–2013); Aberdeen, ID (2011–2012 and 2012–2013); and Parma, ID (2011–2012).

‡ SKCS, single-kernel characterization system.

Table 5. Agronomic performance of barley cultivar Buck and check cultivars across 16 environments in the Winter Barley Germplasm Nursery (7 high rainfall, 9 irrigated).†

Cultivar	Yield	Heading date	Plant height	Test weight	Lodging	Brackling	Protein	Winter survival
	kg ha^{-1}	d from 1 Jan.	cm	kg hL^{-1}	%	%	%	%
Alba	8144	134.0	41.8	62.5	25.2	23.5	10.4	93.7
Maja	7418	128.0	38.1	61.9	26.5	66.0	12.3	98.3
Buck	6486	135.0	41.6	73.7	43.8	20.8	11.2	84.4
No. of environments	15	12	15	13	14	6	7	5
LSD (0.05)	717	2.0	1.9	3.2	14.2	25.0	1.9	23.8

† Corvallis, OR (2013–2014, 2014–2015, and 2015–2016; Mount Vernon, WA (2013–2014, 2014–2015, and 2015–2016); Aberdeen and Rupert, ID (2013–2014, 2014–2015, and 2015–2016); Oakley, ID (2015–2016); St. Paul, MN (2013–2014); and Logan, UT (2014–2015 and 2015–2016).

Table 6. Agronomic performance of barley cultivar Buck and check cultivars across seven high-rainfall environments in the Winter Barley Germplasm Nursery.†

Cultivar	Yield	Heading date	Plant height	Test weight	Lodging	Brackling	Protein	Winter survival
	kg ha^{-1}	d from 1 Jan.	cm	kg hL^{-1}	%	%	%	%
Alba	7219	131.0	40.8	60.0	19.5	23.5	10.2	96.7
Maja	5171	122.0	35.6	57.0	30.7	66.1	12.7	97.1
Buck	4967	132.0	40.2	72.0	42.8	20.8	11.1	64.2
No. of environments	6	7	7	6	6	6	6	2
LSD (0.05)	1334	2.6	3.9	6.3	20.1	25.0	2.0	88.9

† Corvallis, OR (2013–2014, 2014–2015, and 2015–2016); Mount Vernon, WA (2013–2014, 2014–2015, and 2015–2016); and St. Paul, MN (2013–2014).

Table 7. Agronomic performance of barley cultivar Buck and check cultivars across nine irrigated environments in the Winter Barley Germplasm Nursery.†

Cultivar	Yield	Heading date	Plant height	Test weight	Lodging	Brackling	Protein	Winter survival
	kg ha^{-1}	d from 1 Jan.	cm	kg hL^{-1}	%	%	%	%
Alba	8760	138.0	42.7	65.0	29.4	nd‡	11.9	91.7
Maja	8915	136.0	40.4	66.0	23.3	nd	10.4	99.1
Buck	7498	140.0	42.9	75.0	44.5	nd	11.7	97.9
No. of environments	9	5	8	7	8	0	1	3
LSD (0.05)	622	1.6	1.5	3.0	21.0	–	–	17.9

† Aberdeen and Rupert, ID (2013–2014, 2014–2015, and 2015–2016); Oakley, ID (2015–2016); and Logan, UT (2014–2015 and 2015–2016).

‡ nd, no data.

inoculation with five leaf rust isolates at the USDA-ARS Cereal Disease Laboratory revealed that Buck was resistant to four of five isolates (data not shown). In the WBGN, Buck was significantly more resistant to leaf rust than Alba or Maja (Table 9).

Winter Survival

Differential winter survival was observed in 5 of the 13 environments in the OFOOD trial. In these environments (Pullman, WA; Aberdeen and Parma, ID), the winter survival of Buck was lower than that of the checks but not significantly different (Table 8). In the WBGN, differential winter survival was observed at 5 of the 16 environments (Mount Vernon, WA; Aberdeen and Oakley, ID; and St. Paul, MN). In the high-rainfall environments, the winter survival of Buck was lower than that of the checks but not significantly different (Table 6).

Food Quality

For the OFOOD trial, Buck had a significantly lower percentage grain protein than #STRKR across all growing conditions (Table 1). Buck had similar levels of grain β-glucan to #STRKR and Maja across all growing conditions and significantly lower levels compared with Alba (Table 1). Buck had a significantly lower solvent retention capacity for water than Alba across all growing conditions (Table 1). Across all growing conditions, Buck had significantly softer kernels than Alba and Maja (Table 1). In 2006, the US Food and Drug Administration approved a health claim for barley that allows "foods containing barley to claim that they reduce the risk of coronary heart disease. Specifically, whole grain barley and dry milled barley products such as flakes, grits, flour, and pearled barley, which provide at least 0.75 g of soluble fiber per serving" (21 C.F.R. 101.81) (Ames and Rhymer, 2008; National Barley Foods Council, 2003). To receive the daily recommended soluble fiber, a person would have to eat approximately 17 g of steamed grain or 44 g of bread made with 40% barley flour based on the average β-glucan content of Buck.

In the WBGN, grain protein was the only food quality trait measured. In all growing conditions, Buck did not have a significantly different percentage grain protein from the checks (Table 5).

Malting Quality

As a naked cultivar, Buck would not typically be considered for malting and brewing. However, with the expansion in the craft malting and brewing industry, there has been interest in nontraditional types of barley for malting. Buck was malted by the CCRU from three harvests (2013, 2014, and 2015) and five locations (Corvallis, OR; Rupert, ID; Pendleton, OR; and two farms—Jepsen and Starvation Farms—in Morrow County, OR) for a total of seven environments. Data are presented in Table 10. The high malt extracts may be of great interest to maltsters and brewers. The modest levels of enzymes could appeal to all-malt brewers. The wort β-glucan levels could perhaps be reduced with alterations in malt protocol. Buck malt could be used as a percentage of the total malt bill in traditional lauter tun brewing. Breweries equipped with mash filter systems could potentially use an all-naked malt bill. Further research is needed to optimize malting and brewing protocols for naked malts.

Table 8. Reaction of barley cultivar Buck and check cultivars to barley stripe rust (rated at Corvallis, OR, in 2011–2012 and 2012–2013 and Lewis-Brown, OR, in 2011–2012), and scald (rated at Corvallis, OR, in 2011–2012 and 2012–2013 and Lewis-Brown, OR, and Mount Vernon, WA, in 2011–2012), and winter survival (rated at Pullman, WA, and Aberdeen, ID, in 2011–2012 and 2012–2013 and Parma, ID, in 2011–2012) in the Oregon Food Barley trial.

Cultivar	Barley stripe rust	Scald	Winter survival
	%	1–9†	%
#STRKR	6.7	7.1	92.0
Alba	3.3	0.9	97.9
Maja	0.0	6.8	93.0
Buck	3.3	4.6	80.9
No. of environments	3	4	5
LSD (0.05)	9.4	2.6	23.1

† Scald rating on a scale of 1 to 9, where 1 = most resistant and 9 = most susceptible.

Table 9. Reaction of barley cultivar Buck and check cultivars to barley stripe rust (rated at Corvallis, OR, in 2013–2014 and 2014–2015 and Mount Vernon, WA, in 2015–2016), scald (rated at Corvallis, OR, in 2013–2014, 2014–2015, and 2015–2016 and Mount Vernon, WA, in 2013–2014 and 2015–2016), and leaf rust (rated at Mount Vernon, WA, in 2013–2014, 2014–2015, and 2015–2016) in the Winter Barley Germplasm Nursery.

Cultivar	Barley stripe rust	Scald	Leaf rust
	%	1–9†	%
Alba	0.0	0.6	60.4
Maja	0.0	5.5	88.9
Buck	0.0	4.2	13.3
No. of environments	3	5	3
LSD (0.05)	0.0	2.6	45.2

† Scald rating on a scale of 1 to 9, where 1 = most resistant and 9 = most susceptible.

Table 10. Malt quality performed by the Cereal Crops Research Unit on Buck from seven environments (Corvallis, OR, in 2013, 2014, and 2015; Rupert, ID, in 2014; Pendleton, OR, in 2014; and Jepsen and Starvation Farms in Morrow County, OR, in 2015).

Location	Year	Plump on 6/64″	Malt extract	Wort clarity	Barley protein	S/T†	DP†	Alpha-amylase	β-glucan	FAN†
		%	%		%	%	°ASBC	20°DU‡	ppm	ppm
Corvallis, OR	2013	87.2	85.9	2	10.9	33.3	68	49.9	499	110
Corvallis, OR	2014	54.1	84.9	2	10.9	35.1	67	31.7	791	125
Corvallis, OR	2015	44.6	85.8	2	11.0	37.7	100	45.7	477	194
Rupert, ID	2014	68.7	87.9	nd§	11.7	63.8	113	60.1	293	155
Pendleton, OR	2014	51.3	85.9	3	11.5	35.8	75	39.9	334	153
Jepsen Farm	2015	61.3	86.9	3	10.8	37.1	74	43.9	516	127
Starvation Farm	2015	15.3	86.4	3	9.7	44.0	61	50.6	290	144
Mean		54.6	86.2	3	10.9	41.0	80	46.0	457	144

† S/T = ratio of soluble to total protein; DP = diastatic power; FAN = free amino nitrogen.

‡ DU = dextrinizing unit.

§ nd = no data.

Availability

Breeder seed of Buck is maintained by the Barley Breeding Program at Oregon State University, Corvallis, OR 97331. Seed for research purposes will be available on request from the corresponding author for at least 5 yr. Buck has been deposited in the USDA-ARS National Center for Genetic Resources Preservation, where it will be available for distribution 5 yr from the date of this publication. It is requested that an appropriate recognition of source be given when Buck contributes to the development of new germplasm or cultivars.

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