

Registration of 'Alba' barley

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ABSTRACT

'Alba' (Reg. No. _____) is a winter, six-row barley released by the Oregon Agricultural Experiment Station in 2012. The name "Alba" was chosen due to the bright and attractive appearance of the crop at maturity. In high rainfall environments, it has a notable yield advantage over check varieties and maintains excellent test weight and kernel sizing. These advantages are, in part, attributable to resistance to barley stripe rust (incited by *Puccinia striiformis* f. sp. *hordei*) and scald (incited by *Rhynchosporium commune*). The principal end-use of Alba grain is as feed, but it could also be used for food (after pearling) and preliminary tests show that it can be successfully malted and used in craft brewing.

'Alba' (Reg. No. _____) is a winter, six-row barley released by the Oregon Agricultural Experiment Station in 2012. The name "Alba" was chosen due to the bright and attractive appearance of the crop at maturity. "Alba" is derived from the Latin word for "white," and means "dawn" in Spanish. Prior to being named, Alba was tested under the experimental designations "OR77" and "TCFW6-002." In high rainfall environments, it has a notable yield advantage over some varieties, and it maintains excellent test weight and kernel sizing. These advantages are, in part, attributable to resistance to barley stripe rust (incited by *Puccinia striiformis* f. sp. *hordei*) and scald (incited by *Rhynchosporium commune*). The principal end-use of Alba grain is as feed, but it could also be used for food (after pearling) and preliminary tests show that Alba can be successfully malted and used in craft brewing.

Pedigree records show that Alba was derived from a cross made in 1997 between 'Strider' (released by the Oregon Agricultural Experiment Station in 1997), and 'Orca' (Hayes et al. 2000). Strider is a six-row, compact spike, winter growth habit, feed variety with low temperature tolerance comparable or superior to other commercially available varieties. Strider requires vernalization and long days to transition from the vegetative to the reproductive state. Strider has exceptionally poor malting quality, with almost no detectable enzyme activity in malt (Filichkin et al. 2010). Strider is resistant to stripe rust, moderately resistant to scald, and can show severe symptoms of Barley Yellow Dwarf Virus (BYDV). Orca is a two-row, erect spike, spring growth habit feed cultivar. Orca does not require vernalization to transition from the vegetative to the reproductive state (Hayes et al. 2000). Orca is resistant to stripe rust with mapped adult plant resistance QTL on chromosomes 4H and 5H, moderate resistance to scald, and it has the *Ryd2* gene for resistance to BYDV (Hayes et al. 2000).

Methods

Generation Development and Line Selection

The cross between Strider and Orca was made in 1997. From the F1 generation until head-row purification, all generations were fall-planted under field conditions at the Oregon State University Hyslop Farm, near Corvallis, OR USA. The F2 was planted as a bulk population of several thousand plants. Selected F2 heads were threshed and bulked and grown as an F3 population. Selected F3 heads were grown as F4 head rows. Selected F4 head rows were harvested in bulk and advanced to a preliminary yield trial. Selections moved through subsequent cycles of replicated, multi-environment yield testing in Oregon and in the fall of 2004 one of the selected Strider/Orca sibling lines (F7) was designated as OR77 and tested regionally in replicated yield trials.

Seed Purification and Increase

Five hundred F10 heads were selected from OR77 plots and planted for head row purification and increase in the fall of 2007. Seed from one head from one row (F11) was used for Single Nucleotide Polymorphism (SNP) genotyping under the auspices of the USDA-NIFA Triticeae Coordinated Agricultural Project (<http://www.triticeacap.org/>), and these data are available at the T3 database (<http://triticeatoolbox.org/barley/>). In the T3 database Alba is designated as TCFW6-002. One thousand F11 heads were harvested from selected rows, threshed individually and transferred to the Washington Crop Improvement Association for production of F12 Breeder's seed.

Statistical Analyses

All statistical analyses were conducted using R version 3.0.1. Alba was compared with ‘Maja’, Strider, ‘Eight-Twelve’ (Wesenberg et al. 1992), and ‘Charles’ (Obert et al. 2006) for agronomic traits in 33 environments over the years 2008-2012, although not all traits were measured in all years. Eight-Twelve and Charles were chosen by AMBA as the yield and malt quality checks, respectively, at the time these trials were conducted. Alba, Maja, and Strider were tested for low temperature tolerance in controlled freeze tests at the Martonvasar Research Institute (MRI; Hungary) in 2006 and 2008. Eight-Twelve and Charles were tested for low temperature tolerance in controlled freeze tests at the MRI, in 2006 and 2008 respectively. Low temperature tolerance was also recorded in eight field trials where differential survival occurred. In 2013 Alba, Maja, and “Full Pint,” were evaluated for leaf rust resistance at the Northwestern Washington Research and Extension Center, Washington State University, Mount Vernon, WA (WSU Mount Vernon). The malt quality of composite samples from Alba, Maja, and Charles was compared in 10 environments over the years 2009-2011. For the purposes of this report, two trials grown at the same location but in different years, or under substantially different growing conditions, are considered as different environments. The mean of measurements collected from each environment for each cultivar were used for mean separation based on LSD ($p = 0.05$) except for the leaf rust data, where there was a single replicated experiment.

Characteristics

Botanical Description

Phenotypic selection for agronomic type and performance in the progeny of this wide cross (winter/spring and two-row/six-row define the principal germplasm groups of barley) resulted in a six-row barley with rough awns and a lax spike. Alba has a winter growth habit,

meaning it requires vernalization to flower in an agronomically acceptable time frame. Alba has grain with adhering hulls, a white aleurone, short rachilla hairs, and rough awns.

Agronomic Performance

Across all 33 environments, Alba demonstrated a significantly higher yield than Charles. Grain from Alba had significantly higher test weight than all varieties except Maja, and higher plumpness than Maja and Eight-Twelve. Alba was significantly taller than Charles, and taller than other varieties, although the differences were not significant. Alba's heading date was later than that of the other varieties in these tests, although these differences were not significant. Alba had a lower lodging percentage than every cultivar except for Maja, although this difference was not statistically significant (Table 1).

In high-rainfall environments (Brownsville, Corvallis, and Junction City, OR), where the average rainfall is greater than 800 mm year⁻¹ (Western Regional Climate Center), Alba had a significantly higher yield than Eight-Twelve and Charles and a higher (but not significantly higher) yield than Maja and Strider. Alba had the highest test weight of any of the five varieties, but the difference was significant only for the comparison with Eight-Twelve. Alba had significantly higher kernel size than Maja, Strider, and Eight-Twelve (all six-rows) and a higher (but not significantly higher) size than Charles (a two-row). Alba was significantly taller and later maturing than the other varieties but in the two experiments where lodging was observed, it had the lowest lodging percentage. Variable within-trial lodging at the limited number of sites where lodging occurred precludes a robust statistical comparison of means (Table 2).

Pendleton, OR and Pullman, WA are classified as dryland locations because no irrigation is applied and the long-term rainfall averages are 420 mm year⁻¹ and 540 mm year⁻¹ (Western

Regional Climate Center). These environments are typical of optimum dryland environments in the Pacific Northwest of the US and results cannot be extended to truly dry areas (e.g. the summer–fallow zones). At the irrigated locations (Hermiston, OR; Aberdeen, Burley, Filer and Kimberly, ID; and Fort Collins, CO) supplemental irrigation is routinely applied in accordance with local practice since average annual rainfall is below 400 mm. Under dryland (Table 3) and irrigated (Table 4) environments, there were no significant differences between varieties for yield, although Strider consistently had the highest average yield. As expected, all varieties were higher yielding under irrigated conditions, with Alba showing a 13.3% advantage. The test weight advantage of Alba over the other varieties was not as apparent under dryland or irrigated conditions as it was under high rainfall: other varieties improved in test weight relative to high rainfall whereas Alba maintained an excellent test weight in all three types of environments. Under dryland and irrigated conditions, Alba was second only to Charles in kernel plumpness. Alba consistently had superior kernel plumpness to the other six-rows, particularly in comparison to Maja and Eight-Twelve under dryland conditions. In terms of plant height, Alba was consistently the tallest, but the differences between Alba and the other varieties were not as great as under high rainfall conditions. Likewise, Alba was the latest, or among the latest to flower, but these differences were not as great as under high rainfall conditions and the differences were generally not significant. Finally, lodging percentages for the varieties were variable and non-significant, reflecting the variability of this trait within environments.

In eight field environments, the low temperature tolerance of Alba was superior to, but not statistically different from, that of the other four varieties. Differential winter survival data are very difficult to obtain. The Corvallis location rarely experiences sufficiently low temperatures to cause winter injury in varieties with some level of cold tolerance. The high

survival values in field trials that experienced differential winter survival over four years of testing indicate that Alba has a level of low temperature tolerance at least comparable to that of other commercially available winter barley varieties (Table 5). In addition to field data, we present the results from two controlled freeze tests (Table 6). While controlled freeze test data can only approximate field conditions, they do generally provide a meaningful ranking of cultivar performance.

Disease Resistance

Alba and Strider displayed significantly better resistance to scald than Maja, Eight-Twelve, and Charles in five years of testing under intense natural epidemic conditions at Corvallis, OR (Table 7). For scald, plants were rated on a 1 (resistant) to 9 (susceptible) disease reaction score in each of these environments. For stripe rust, plants were rated based on percent of leaf area that was covered by lesions at anthesis. Alba has a slightly lower scald rating than Strider, the resistant winter parent. Alba was significantly more resistant to stripe rust than Eight-Twelve (the susceptible check) and had less stripe rust than Charles. It had a slightly higher percent severity than Strider and a slightly lower percent severity than Maja, although all three levels of resistance are excellent. Alba, Maja, and Strider were all developed at Oregon State University and selected for maximum levels of adult plant resistance to stripe rust. Alba is susceptible to leaf rust (incited by *Puccinia hordei*). However, in trials at WSU Mount Vernon in 2013, Alba showed a significantly lower percent severity than Maja (Table 8).

Malt Quality

Alba was included in malting quality tests in 10 environments (Table 9). Eight-Twelve

was not included in the malting quality analyses because it had previously been determined to have poor quality, and the tests are expensive. Charles is currently the AMBA winter barley check for malting quality. At the time these tests were conducted, Maja was a six-row facultative growth habit candidate cultivar for AMBA approval. Alba was included in the ten malt analyses because it is a parent of germplasm involved in genetic studies of malting quality. Alba does not meet current standards for malting barley as established by AMBA. It is lower in malt extract, soluble/total protein ratio, diastatic power and alpha amylase and higher in malt beta glucan than AMBA guidelines (AMBA 2010). However, lower soluble protein and enzyme levels have also been noted by AMBA as a priority for the Craft Brewing industry. Preliminary results from tests involving changes to malting and brewing protocols indicate that Alba grain can produce excellent malt and beer (M. Doehnel and W. Carpenter, Skagit Malting and Brewing, personal communication).

Feed, Forage and Food Quality

The limited data that are available for Alba feed, forage, and food quality can be found at “<http://barleyworld.org/breeding-genetics/data>”.

Availability

Breeder seed is maintained by the Barley Project at Oregon State University, Corvallis, OR 97331. Seed for research purposes will be available on request from the corresponding author for at least 5 years. It is requested that appropriate recognition of source be given when this cultivar contributes to development of new germplasm or cultivars.

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For Review Only

Tables

Cultivar	Yield	Test Weight	Plump	Plant Height	Heading Date	Lodging
	kg ha ⁻¹	g L ⁻¹	%	cm	Julian Days	%
Alba	7412.2	669	90.3	102.8	149.3	16.4
Maja	6858.9	663	75.6	96.4	145.2	16.2
Strider	7522.7	644	82.4	96.3	146.1	21.0
Eight-Twelve	6804.7	630	74.1	95.3	146.0	21.0
Charles	6262.6	639	92.0	85.4	144.9	26.2
# of trials	33	28	28	28	23	20
LSD ($p=0.05$)	871.7	21	10.1	7.8	7.0	18.4

Table 1. Agronomic performance of Alba and check cultivars across 33 environments (7 high rainfall, 7 dryland, and 19 irrigated).^t

^tBrownsville, Corvallis, Hermiston, Junction City and Pendleton, OR; Pullman, WA; Aberdeen, Burley, Filer and Kimberly, ID; and Fort Collins, CO.

Cultivar	Yield	Test Weight	Plump	Plant Height	Heading Date	Lodging
	kg ha ⁻¹	g L ⁻¹	%	cm	Julian Days	%
Alba	6846	666	90.6	121.7	137.8	28.0
Maja	5961	640	56.1	106.3	125.6	50.0
Strider	6435	610	67.1	106.1	129.6	48.0
Eight-Twelve	4156	562	42.7	110.0	127.6	50.0
Charles	5008	603	86.6	89.6	120.2	63.0
# of trials	7	7	7	7	5	2
LSD ($p=0.05$)	1566	57	22.9	12.8	4.1	150.6

Table 2. Agronomic performance of Alba and check cultivars across 7 high rainfall environments.^t

^tBrownsville, Corvallis and Junction City, OR.

Cultivar	Yield	Test Weight	Plump	Plant Height	Heading Date	Lodging
	kg ha ⁻¹	g L ⁻¹	%	cm	Julian Days	%
Alba	6806	673	84.7	101.6	152.3	21.5
Maja	6290	679	76.0	94.3	149.3	19.8
Strider	7084	662	81.3	100.5	150.7	19.5
Eight-Twelve	6204	650	73.1	95.1	149.7	31.5
Charles	6245	645	91.7	87.1	150.0	27.2
# of trials	7	7	7	7	3	6
LSD ($p=0.05$)	1059	28	20.3	17.1	4.3	38.4

Table 3. Agronomic performance of Alba and check cultivars across 7 dryland environments.^t

^tPendleton, OR and Pullman, WA.

Cultivar	Yield	Test Weight	Plump	Plant Height	Heading Date	Lodging
	kg ha ⁻¹	g L ⁻¹	%	cm	Julian Days	%
Alba	7844	666	92.9	93.9	152.6	11.8
Maja	7399	668	85.2	92.1	150.9	8.8
Strider	8085	652	90.5	88.8	150.7	17.3
Eight-Twelve	8002	653	90.3	88.1	151.5	10.8
Charles	6731	655	94.8	82.4	152.1	19.6
# of trials	19	14	14	14	15	12
LSD (<i>p</i> =0.05)	1163	20	8.5	8.9	5.7	17.8

Table 4. Agronomic performance of Alba and check cultivars across 19 irrigated environments.[†]

[†]Hermiston, OR; Aberdeen, Burley, Filer and Kimberly, ID; and Fort Collins, CO.

Cultivar	Low Temperature Tolerance
	% survival
Alba	78.3 (12-96)
Maja	76.1 (33-100)
Strider	73.1 (16-100)
Eight-Twelve	72.5 (23-100)
Charles	60.9 (9-93)
# of trials	8
LSD (<i>p</i> =0.05)	29.43

Table 5. Low temperature tolerance at Aberdeen, ID; Pullman, WA; Hermiston and Pendleton, OR; St. Paul, MN; and Bozeman, MT over the years 2008-2011. Ranges are listed in parentheses. Low temperature tolerance was only recorded in environments where differential survival was observed.

Cultivar	MRI '06	MRI '08
	% survival	% survival
Alba	85	87
Maja	78	75
Strider	58	98
Eight-Twelve	82	-
Charles	-	31

Table 6. Percent survival in controlled freeze tests at the Martonvasar Research Institute (Hungary), in 2006 and 2008. Charles and Eight-Twelve were not included in the 2006 and 2008 tests, respectively.

Cultivar	Scald	Stripe Rust
	1-9 ^t	%
Alba	1.6 (1-3)	0.4 (0-2)
Maja	4.8 (1-7)	2 (0-7)
Strider	2 (1-4)	0 (0-0)
Eight-Twelve	5.4 (3-7)	59.6 (0-97)
Charles	7.4 (4-9)	17.6 (0-63)
# of trials	5	5
LSD ($p=0.05$)	2.3	31.2

Table 7. Disease ratings for scald (*Rhynchosporium commune*) and percent severity for barley stripe rust (*Puccinia striiformis* f. sp. *hordei*) at Corvallis, Oregon, 2008-2012. Ranges are listed in parentheses.

^t1 = most resistant, 9 = most susceptible

Cultivar	Leaf Rust
	%
Alba	75 (75-75)
Maja	93 (90-95)
Full Pint (BCD47)	0.33(0-1)
# of replicates	
p -value	0.002

Table 8. Percent severity for barley leaf rust (*Puccinia hordei*) from a single replicated trial at WSU Mount Vernon, WA, 2013. Ranges are listed in parentheses.

Cultivar	Malt extract	Barley protein	Wort protein	Soluble/total protein	Diastatic power	α -amylase	β -glucan
	%	%	%	%	°ASBC	D.U.	mg L ⁻¹
Alba	78.3 (72.7-81.7)	10.5 (8.3-13.8)	3.6 (3.1-4.2)	36.4 (26.8-48.8)	91.4 (67.0-126.7)	43.3 (34.6-70.6)	466.4 (111.0-720.3)
Maja	79.4 (77.0-81.7)	11.0 (8.7-14.8)	4.1 (3.6-4.7)	40.5 (33.4-47.8)	130.3 (109.0-164.6)	51.6 (38.3-67.9)	102.9 (43.1-179.6)
Charles	81.7 (79.3-83.6)	11.3 (9.8-13.2)	4.9 (4.6-5.5)	47.0 (38.3-57.7)	125.5 (92.8-159.9)	84.1 (73.0-97.0)	165.2 (51.5-310.1)
# of trials	10	10	10	10	10	10	10
LSD ($p=0.05$)	1.7	1.4	0.3	5.0	16.5	8.4	119.9

Table 9. Malting quality profile of Alba compared to other cultivars grown at Corvallis, Hermiston and Pendleton, OR; Aberdeen, ID; and Pullman, WA; over the years 2009-2011.