Plant Variety Release
LONTRA

Crop name: Barley
Experimental designation of variety: DH142010
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Introduction

Development and release of malting barley varieties geared towards the craft malting and brewing industries offers an alternative to the traditional malting barley assessment pipeline established by organizations such as American Malting Barley Association (AMBA). As the craft industries grow, they seek opportunities for market differentiation and have actively encouraged barley breeders to develop lines more suitable for their products (Brewers Association, 2014). Additionally, craft maltsters are obliged to secure at least half of their barley from within a 500 mile radius of their facility and need access to locally adapted varieties (Thomas, 2019). There have been a few varieties released that have been geared towards craft maltsters, notably the winter-habit Avalon out of Virginia Tech and the spring-habit Butta-12 out of UC-Davis, both of which are adapted to areas outside of the primary barley growing regions of the US Mountain-West and the Canadian Prairie. These have both been embraced by craft maltsters with positive comments about their flavor contributions, but these are the exception rather than the rule (Gallagher et al., 2020; Manning, 2022). Lontra was evaluated in multiple environments but has performed particularly well in the Klamath Basin on the Oregon and California border. This region has a history of growing malting barley, and while greatly reduced from its peak, there is interest in increasing acreage, particularly of winter barley.

Lontra is a selection from a population of doubled haploids developed from crosses between Maris Otter® (winter, two-row, malting variety) and two elite malting cultivars: the AMBA listed, winter, two-row variety LCS Violetta (Limagrain Cereal Seeds, 2022) and the experimental line 04-028-36, a winter, two-row selection from Ackermann Saatzucht GMBH & CO. The heritage malting barley variety Maris Otter is lauded by brewers for its flavor and brewhouse performance. It is arguably the most well-known malting barley variety of the 20th century and is considered by some to be the “Rolls-Royce of malts”. Soon after its release in 1960’s, Maris Otter became the dominant winter malting barley in the United Kingdom but over time was surpassed agronomically by contemporary varieties, eventually falling off the U.K.’s recommended list in 1989 (Hornsey, 2012). While no longer listed, it maintains a small, but notable market share and, as of 2020, made up 1.9% (31,261mt) of all U.K. malting barley purchases, the largest percentage of any variety not currently recommended by MAGB (Maltsters’ Association of Great Britain, 2019). Current market interest for this and other heritage varieties has spurred interest in the contributions of these heirlooms to beer flavor and in the potential of capturing these attributes in contemporary varieties.

Despite the perception of certain malting barley varieties contributing positively to beer flavor, the scientific evaluation of this connection is fairly novel. Herb et al. (2017) showed that barley genotype contributes to beer flavor, and in a series of follow-up studies this team confirmed and expanded upon this contribution (Bettenhausen et al., 2020; Morrissy et al., 2021; Sayre-Chavez et al., 2022; Windes et al., 2020). This research utilized a workflow of malting, brewing, sensory, and metabolomics that was utilized to expand the evaluation of potential varieties for the craft malting and brewing industry.

Malting barley varieties in the US are typically evaluated through a pipeline established by AMBA to recommend varieties. While this pipeline is very effective at identifying lines that will meet the needs of the majority of their members, it is not designed for evaluation of niche lines of interest to subsets within the malting and brewing supply chain. Craft maltsters and brewers are interested in novel barley varieties that provide marketable traits to their consumers (Craine et al., 2022). Working with industry and research collaborators, an alternate path for releasing varieties relevant to the craft malting, brewing, and distilling industries has been developed. The OSU breeding program previously released

Full Pint and Oregon Promise, based on their positive contributions to beer flavor (Bettenhausen, Benson, et al., 2020; P. Hayes, 2014; P. M. Hayes et al., 2020). Oregon Promise has also garnered interest for its heirloom heritage as it was a doubled haploid developed from a cross between the notable U.K. variety Golden Promise® and Full Pint.

Lontra meets many of the commercial desires of the craft industries as it provides four unique attributes: 1) it has shown agronomic success in the Klamath Basin, an area of interest to a large California craft-malting operation; 2) is a daughter of the heritage malting barley, Maris Otter, and thus has market interest associated with its parent; 3) meets malt quality expectations in both standard and traditional malting processes; and 4) has performed well in flavor evaluation trials.

Plant Description and Performance

Crosses of Maris Otter with Violetta and 04-028-36, respectively, were made in 2013 and a population of 85 doubled haploids was developed in 2014 and 2015. Doubled haploids were produced via anther culture following the methods of Cistué et al. (2003). The 85 selections were grown in the greenhouse and subsequently planted in field mini-plots (2.3 m^2). Of these, 47 were selected for a preliminary yield trial (9.3 m^2 plots): 39 of Violetta/Maris Otter and eight of 04-028-36/Maris Otter. Of the 47 initial selections, 10 were selected to advance to a replicated yield trial: seven of Violetta/Maris Otter; three of 04-028-36/Maris Otter. Finally, four selections, two of Violetta/Maris Otter and two of 04-028-36/Maris Otter, were advanced to a trial that included a full suite of agronomic, malting, brewing, sensory, and chemical analysis; the results of which are outlined by Morrissy et al. (2021).

Field trials at various stages were performed primarily at agricultural extension centers: the OSU Hyslop Crop Science Field Research Lab (Corvallis, OR, USA); the Columbia Basin Agricultural Research Center (Pendleton, OR, USA); and the UC Intermountain Research and Extension Center (Tulelake, CA, USA). Additionally, on-farm trials were held at the Herb Farm (Lebanon, OR, USA). Detailed field trial information and agronomic data collection methodology can be found in previous manuscripts from this research group (Halstead et al., 2022; Morrissy et al., 2021).

a. Malting and malt analysis

A variety of methods and batch sizes were used to produce malt evaluated over the course of life cycle of this variety evaluation. Malting batch size is as defined by Morrissy et al. (2022) and is briefly, micro-scale (<1kg); mini-scale (<150kg); and commercial-scale. Micro-scale malting was performed at OSU and at the CCRU (Madison, WI, USA) using their respective malting protocols. Mini-scale malting was performed in 2019 at OSU and in 2021 at Admiral Maltings (Alameda, CA, USA) and the protocols are outlined in the respective publications by Morrissy et al. (2021, 2022).

Malt analysis was performed either at the CCRU or at Hartwick College Center for Craft Food and Beverage; each followed ASBC methods of analysis (American Society of Brewing Chemists, n.d.). All analysis was benchmarked against the AMBA guidelines for all-malt brewing (AMBA, 2020). Malt parameters were used to calculate malt index scores based on the CCRU scoring system (maximum value = 70) (CCRU, 2022). This system assigns a numerical score to the results of each assay based on an established range that reflects the needs of all-malt brewers; the higher the score, the more appropriate the malt is for all-malt brewing.

b. Brewing and beer analysis

Beers were brewed and analyzed with Lontra and other experimental lines in 2020 and 2021 by Deschutes Brewery and Seismic Brewing Co respectively. Brewing protocols are described by Morrissy et al. (2021, 2022). Analysis of beers was performed using ASBC methods of analysis by the industry partners. Sensory was also performed by the industry partners following their established methods.

c. Statistical analysis

Data was assessed using ANOVA and mean comparisons were performed using Fisher's LSD. All statistical analysis was performed using the R environment for statistical computing (R Core Team, 2020).

2. Characteristics

a. Agronomics

The 47 doubled haploids selected for a preliminary yield trial were evaluated against a control, Wintmalt (AMBA listed, winter-habit, 2-row), in harvest year 2017 at the Corvallis, OR and Lebanon, OR field sites. From this a subset was selected for trials in 2018 and then culled again for another pair of trials in 2019. For 2018 and 2019, trials were replicated (two per entry) in Corvallis and were planted as single-replicate in Lebanon. The results of Lontra compared to Wintmalt are shown in Tables 1a and 1b. Average plant height and test weight at both locations across all years were similar for both Lontra and Wintmalt. The three-year average yield in Corvallis was similar between the two varieties, but Lontra yielded substantially higher in 2019 while Wintmalt was higher in 2018. At the Lebanon field site, average yield was higher for Lontra, but data is skewed by an overall poor year in 2019 when lodging was problematic for all entries and especially so for Wintmalt. Lontra had higher average grain protein at both locations, but was still in specification for all-malt brewing (≤12.0%). Over the three years Lontra appears more resistant to scald (incited by *Rhynchosporium commune)* compared to Wintmalt, with a noticeable difference at Corvallis and a slight difference at Lebanon. They showed tolerant to susceptible reactions in 2018, but in 2019 at Corvallis differences were more striking: Wintmalt 80% and Lontra 13%. Scald was not observed at Lebanon in 2019. Lontra appears to have some resistance to stripe rust (incited by *Puccinia striiformis* f. sp. *hordei*), although this disease was not severe during test years in Oregon and only one year of data are available from Davis, California (Tables 1 and 2). In these tests Lontra has had less stripe rust than the susceptible check (Wintmalt) and Thoroughbred and is more similar to the resistant check (Lightning). Stripe rust was not observed on Lontra in subsequent years of testing at Corvallis. BYDV and other diseases were not observed on Lontra during testing. Lodging and brackling were also similar between the varieties, with Lontra slightly less likely to lodge than Wintmalt. Lontra outperformed Wintmalt for plump kernels (~6% higher at each site) and Lontra was only out of specification for one station-year.

Lontra was advanced into the Oregon Malt Elite Trials (OMELT) for the 2020 and 2021 harvest years and benchmarked against three AMBA recommended varieties (Endeavor, Thunder, and Wintmalt). Data from the replicated field trials in Corvallis are shown in Table 3. There was a significant variety by year interaction effect for scald, lodging, brackling, and yield and a significant line effect for heading date. Test weight, plump/thin, and protein were only measured on one plot from each entry and thus were not analyzed using statistical tools. Generally, lines performed better in 2021 than 2020 as scald, lodging, and brackling were lower and yields were greater. Lontra outperformed the AMBA checks in 2020 with a 2,808 kg/ha yield advantage over the next highest line. In 2021 there was minor disease pressure and no lodging, and Lontra yielded similarly to Endeavor but was out-yielded by Thunder and Wintmalt. Notably, Lontra's 2020 yield was the third highest among the eight variety x year combinations and its 2021 yield was the fourth highest. In 2020, Lontra was the only entry to meet AMBA guidelines for plump and thin, but it did exceed the all-malt guidelines for grain protein. All entries were similar for plump and thin in 2021 and met malting guidelines; Lontra again exceed the protein guideline and was the highest of the four varieties.

To further assess the variety, agronomic quality data relevant to malting was gathered in harvest years 2020 and 2021 at the Tulelake field site, an intended production area (Table 4). Lontra was evaluated against two released varieties and elite experimental germplasm from the OSU breeding program – two others in 2020 and four others in 2021. In 2020, grain protein, test weight (TW), and plump (>6/64") differed significantly between lines, however yield did not differ significantly among the five entries. Lontra was in the higher of two protein groupings (with Lightning) but all entries were suitable for all-malt brewing (≤12.0%). It did separate from all other entries as the least plump grain but was considered acceptable for malting (≥90%). It is notable that there were no significant differences in yield as the evaluation included the AMBA listed Thunder, a variety contracted on commercial acreage in the region. Results for the 2021 harvest showed significant separation for protein, TW, and yield. Lontra yielded close to the overall year average and out-yielded Lightning but yielded less than Thunder. Overall protein was greater in 2021 but Lontra's grain protein was similar between years. Lontra fell near the average among entries and was only significantly greater than Thunder. However, as with 2020, grain protein for all entries did not exceed 12.0%.

In harvest year 2022, Lontra was planted on a larger scale (0.40ha) at the IREC but only as a single replicate. This trial was evaluated against a smaller strip of Thunder barley also planted as one replicate at the IREC (Table 5). Both of these large strips were planted with the intention to be harvested for commercial malting trials. Yield for Lontra was higher than the replicated plot average in 2020 but lower than 2021 and generally represents a stable yield performance year over year. Grain protein content was also stable compared to 2020 and 2021. Thunder had a higher yield but showed similar grain protein, plump kernels, and test weight. Thunder had a high percentage of thin kernels (4.0%) which exceeded the AMBA guideline (≤3.0%).

b. Malting

Lontra was assessed for malt quality beginning with the 2016 harvest year. In early stages of evaluation, it was assessed under standard malting protocols at the CCRU and benchmarked against AMBA guidelines. Table 6 shows micro malting data from 2016-2019 of Lontra compared to Wintmalt. Lontra met AMBA guidelines for all-malt brewing except for seven instances: extract (2018), S/T (2017-2019), DP (2016, 2019), β-glucan (2018), and FAN (2019). However, other than extract, these results fit within the range of the AMBA adjunct-brewing guidelines. Wintmalt fell outside of AMBA all-malt guidelines at the same rate over the survey. Lontra-2016 scored highest in the all-malt scoring system (68 out of 70) and Lontra averaged slightly higher than Wintmalt over the four years. Using years as replicates there were no significant differences between Lontra and Wintmalt for any of the malting attributes.

Micro-malting was also performed on samples of Lontra grown at three locations (Corvallis, Pendleton, and Tulelake) in harvest year 2020 to evaluate the effect of growing environment on malt quality attributes. Comparisons between Lontra and Thunder are shown in Table 7. Overall Lontra met AMBA all-malt guidelines for more parameters at more locations than Thunder and average malt quality only exceeded the guidelines for two parameters (S/T and FAN) as opposed to four for Thunder (DP, AA, S/T, and FAN). Grain grown in Tulelake produced malt that best met the all-malt specifications based on all-malt score, and within the Tulelake site, Lontra produced malt more suitable for all-malt brewing than Thunder. Lontra's all-malt score was slightly higher than Thunder when averaged across all locations. It should be noted that available seed quantity limited malting replicates to one per location, and thus statistical analysis was not performed.

The trend towards slightly higher proteolytic modification in the micro-malts (shown in both Table 6 and 7) was confirmed in the mini-scale malts produced by Morrissy et al. (2021), with S/T (46.7%) and FAN (210) above the all-malt guidelines but suitable for adjunct brewing. Malts produced in these trials used similar malting protocols as the micro-malts, which were geared towards promoting modification and designed to mimic parameters used by larger malting companies to produce uniform brewing malts. The correlation between steeping regime and overall malt modification is known (Bryce et al., 2010). Given the overall low β-glucan in all entries, these results imply that using an optimized steeping regime can be employed to produce malts more in line with the needs of craft brewers. A protocol designed to reduce steep out moisture should produce Lontra malt with lower proteolytic modification while keeping β-glucan in specification.

Finally, Lontra was evaluated under floor malting conditions using a mini-scale floor-malting protocol designed for variety evaluation by Admiral Maltings. In this assessment Lontra was compared to the AMBA-listed, spring-habit variety CDC Copeland. This variety is regularly contracted by Admiral Maltings in the Klamath Basin. Both lines were malted to a British Pale Ale-style that mimicked Admiral's

“Maiden Voyage” brand malt. Lontra outperformed CDC Copeland with higher extract and lower overall proteolytic modification, more closely meeting desired specifications (Table 8). Lontra did still exceed AMBA guidelines for S/T and FAN, similar to other trials, but Copeland was out of specification for those parameters as well as α-Amylase and extract. Some of CDC Copeland’s malt deficiencies may likely be a result of poor agronomic conditions in 2021 that impacted spring barley more severely than winter (Gous et al., 2015; Wilson, 2020). Lontra grain was more suitable for malting than CDC Copeland with plumper, more homogenous grain. Lontra had a much higher percentage of plump kernels (>6/64”) – 94.9% vs. 80.0% - and a lower percentage of thins (<5/64”) – 0.5% vs. 3.8%.

c. Brewing and sensory

Beers were produced using Lontra in 2020 and 2021 in a series of research projects evaluating the effect of barley variety on beer flavor. The first study by Morrissy et al. (2021) assessed Lontra against three of its siblings and Wintmalt, using a single malt, lightly hopped research recipe designed for varietal differentiation. The beer produced with Lontra met brewhouse performance expectations and performed similarly to the Wintmalt control. In sensory evaluation, the Lontra beer was described as sweet aromatic, sweet, and floral and separated distinctly from its siblings but not from Wintmalt. The second study evaluated the floor malts produced at Admiral Maltings and evaluated Lontra against the spring-habit CDC Copeland using a recipe that more closely resembled the industry partner’s offerings (Morrissy et al., 2022). The Lontra malt performed better in the brewhouse with greater mash efficiency and brewhouse yield. Sensory evaluation found the beers had some significant differences for specific descriptors but the there was no significant difference in overall preference. Both of these studies indicate that while Lontra can provide some unique flavor attributes to beers, it will generally perform as expected in the brewhouse and sensory evaluation relative to current AMBA recommended varieties.

3. Conclusion

Lontra malting barley is a new variety that meets the requirements of craft maltsters and brewers. It is the third line from OSU, after Full Pint and Oregon Promise, to be released primarily for its unique contributions to malt, beer, and spirits – without AMBA approval. Agronomically, it performs similarly to the AMBA-listed varieties Endeavor, Thunder, and Wintmalt, and performed particularly well in the Klamath Basin. Malting assessments found that under standard malting protocols it will meet AMBA adjunct brewing guidelines and most of the all-malt guidelines but is likely to exceed those for proteolytic modification (FAN & S/T). However, unique to this evaluation was its assessment under a floor-malting protocol where it outperformed the AMBA-listed CDC Copeland. The release of Lontra provides a new option for growers in the Pacific Northwest that are interested in planting winter barley for the craft industry.

Seed/plant production

The production of certified classes of seed is proceeding as follows. Breeder seed was produced from head row purification blocks at Hyslop Farm, near Corvallis, Oregon in 2021. Approximately one quarter of an acre of this seed was planted in the fall of 2022 in Othello, Washington by Washington State Crop Improvement Association to produce Foundation seed. This seed will be harvested in 2023. Seed for one acre (~ 50 kg) will be saved for planting a second round of Foundation seed increase in the fall of 2023. The balance will be available for sale as Foundation seed and can be used to produce Registered and/or Certified classes of seed.

Lontra is proposed for release with a non-exclusive license, per previous OSU malting barley varieties. There will be a one-time application fee of $250 for each non-exclusive license. Those interested in a license should contact Denis Sather at the OSU Office of Commercialization and Corporate Development (denis.d.sather@oregonstate.edu). Lontra seed, for planting purposes, can only be sold as a class of certified seed with a royalty of $0.03/lb (approximately $0.067/kg). The $0.03/lb royalty will be paid on sale of this seed. All grain harvested from the certified production must be disposed of by malting or feeding, unless permission is obtained - in writing - from OSU to use the seed for other purposes, including re-planting.

Plant Variety Protection will not be sought for Lontra due to the special status of malting barley in the US, where the malting barley supply chain is based on sale of certified seed. By specifying that all sales for planting purposes must be a class of certified seed we will ensure that growers will be purchasing seed from the seed dealers with non-exclusive licenses. There is not an open market in the US for malting barley that is not grown from a class of certified seed: the risk to the maltster is too great. The variety will be protected by Federal Seed Law and OSU recognized as the owner of the variety. Furthermore, Oregon, Idaho and Washington state trademarks will specify that the variety can only be sold under the name of “Lontra”.

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Table 1. Agronomic data of Lontra and Wintmalt from Corvallis, OR (Table 1a) and Lebanon, OR (Table 1b) in three years of evaluation. Data from the 2017 set is from a single standard yield trial plot, while data from 2018 and 2019 is the mean of two replicated standard plots.

Table 1a. Corvallis, OR

Harvest Year	Variety	Height (cm)	Heading (DOY)	Scald (% of plot)	Lodging (% of plot)	Brackling (% of plot)	Plump (>6/64)	Thin (<5/64)	TW (g/L)	Yield (kg/ha)	Protein (%)
2017	Lontra	82	140	0	0	0	96.0	1.0	653.0	5149.6	8.4
	Wintmalt	85	n.d.	0	0	0	99.0	0.0	654.0	4772.3	9.1
2018	Lontra	96	122	45	5	30	93.5	1.0	653.0	5538.6	10.6
	Wintmalt	98	124	53	0	28	90.5	1.0	675.5	7227.2	9.3
2019	Lontra	101	117	13	18	13	97.3	0.2	642.0	7110.2	10.5
	Wintmalt	92	121	80	35	10	80.1	1.6	578.6	5214.4	9.8
3-yr	Lontra	*93.0*	*126.3*	*19.3*	*7.7*	*14.3*	*95.6*	*0.7*	*649.3*	*5932.8*	*9.8*
Average	Wintmalt	*91.3*	*122.5*	*44.3*	*11.7*	*12.7*	*89.9*	*0.9*	*636.0*	*5738.0*	*9.4*

Table 1b. Lebanon, OR

Harvest Year	Variety	Height (cm)	Scald (% of plot)	Lodging (% of plot)	Plump (>6/64")	Thin (<5/64")	TW (g/L)	Yield (kg/ha)	Protein (%)
2017	Lontra	95	5	0	98.0	n.d.	685.0	7548.0	9.3
	Wintmalt	100	20	0	99.0	n.d.	700.0	7375.0	10.3
2018	Lontra	103	75	90	90.0	1.0	686.0	6207.7	11.6
	Wintmalt	115	75	n.d.	87.0	2.0	687.0	6483.7	9.3
2019	Lontra	105	n.d.	70	82.7	0.6	649.5	4855.8	12.2
	Wintmalt	90	n.d.	90	66.7	1.0	620.6	2655.1	11.7
3-yr	*Lontra*	*101.0*	*40.0*	*53.3*	*90.2*	*0.8*	*673.5*	*6203.8*	*11.0*
Average	*Wintmalt*	*101.7*	*47.5*	*45.0*	*84.2*	*1.5*	*669.2*	*5504.6*	*10.4*

Table 2. Stripe rust disease severity (%) at Corvallis and Lebanon, Oregon (2019, 2020) in OSU yield trials

Variety	Corvallis 2019	Lebanon 2019	Corvallis 2020	Lebanon 2020
Endeavor	8	10	0	5
Wintmalt	13	50	20	20
Thunder	22	60	5	20
Lightning	10	1	5	0
Lontra	0	10	8	0

Table 3. Stripe rust disease severity (%) in the 2020 Barley Stripe Rust Screening Trial at Corvallis, Oregon and Davis, California

Variety	Corvallis	Davis
Thoroughbred	80	80
Wintmalt	50	40
Thunder	28	3
Lightning	10	0
Lontra	25	5

Table 4: Agronomic data comparing Lontra to three AMBA-listed varieties from the Oregon Malt Elite Trials at Corvallis, OR in harvest years 2020 and 2021. Mean separation was performed among parameters that showed a significant Year x Line interaction and were performed across both years.

Variety	Heading (DOY)	Scald (% of plot)	Scald (% of plot)	Lodging (% of plot)	Brackling (% of plot)	Height (cm)	Plump (>6/64")	Thin (<5/64")	TW (g/L)	Yield (kg/ha)
Interaction	n.s.	***	***	***	*	n.s.	-	-	-	*
Endeavor	106.7	88.3^{a}	88.3^{a}	78.3^{a}	53.3^{b}	112.0	56.0	11.6	620.6	5341.6^{d}
Thunder	107.3	95.0^{a}	95.0^{a}	33.3^{b}	78.3^{a}	106.0	73.8	5.4	611.2	5194.7^{d}
Wintmalt	114.0	51.7^{b}	51.7^{b}	33.3^{b}	43.3^{b}	105.0	82.3	3.0	585.8	4865.8^{d}
Lontra	109.7	15.0^{c}	15.0^{c}	6.7^{c}	41.7^{b}	114.7	94.1	0.5	632.2	8150.0^{bc}
'20 Average	*109.4*	*62.5*	*62.5*	*37.9*	*54.2*	*109.4*	*76.6*	*5.1*	*612.5*	*5888.0*
Endeavor	114.7	15.0^{c}	15.0^{c}	0.0^{c}	10.0^{c}	104.7	95.3	0.6	697.9	7846.7^{c}
Thunder	117.7	6.7^{cd}	6.7^{cd}	0.0^{c}	9.3^{c}	108.3	98.7	0.2	703.1	9475.6^{a}
Wintmalt	122.3	8.3^{cd}	8.3^{cd}	0.0^{c}	0.3^{c}	104.0	98.2	0.2	711.1	9081.3^{a}
Lontra	119.7	0.0^{d}	0.0^{d}	0.0^{c}	10.0^{c}	105.0	97.4	0.1	657.4	7876.3^{c}
'21 Average	*118.6*	*7.5*	*7.5*	*0.0*	*7.4*	*105.5*	*97.4*	*0.3*	*692.4*	*8570.0*

Significance codes: *** <0.001; ** <0.01; * <0.05; n.s., not significant. – , indicates a single replicate data set and thus was not analyzed. Letters in superscript annotate mean separation within groups. Entries with the same letter are not significantly different using LSD.

Table 5: Agronomic data from UC-IREC for harvest years 2020 and 2021. A selection of elite malting lines (2020 – 3; 2021 – 5) and the released varieties Thunder and Lightning were evaluated for performance in the region.

2020	Variety/Line	Protein*** (%)	Plump*** (>6/64)	TW*** (g/L)	Yield (kg/ha)
	DH140963	9.5^{a}	97.2^{b}	683.1^{cd}	6494.9
	DH141132	9.7^{a}	96.7^{b}	692.5^{bc}	6902.7
	Lontra	10.7^{b}	93.8^{a}	676.2^{d}	6293.7
	Lightning	10.7^{b}	96.9^{b}	706.2^{a}	5821.5
	Thunder	9.4^{a}	97.7^{b}	695.0^{bc}	6712.2
2021	**Variety/Line**	**Protein*** (%)**	**Plump (>6/64)**	**TW*** (g/L)**	**Yield*** (kg/ha)**
	DH140963	10.9^{b}	99.0	645.2^{e}	8338.7^{b}
	DH141132	10.9^{b}	97.8	656.3^{d}	7891.4^{c}
	DH141222	11.0^{b}	98.7	680.8^{a}	7792.8^{c}
	DH141225	10.9^{b}	98.9	679.7^{ab}	8299.0^{b}
	Lontra	11.1^{b}	93.6	644.7^{e}	7590.6^{c}
	Lightning	11.7^{a}	98.6	677.3^{b}	7192.5^{d}
	Thunder	10.0^{c}	99.2	669.5^{c}	8956.8^{a}

Significance codes: *** <0.001; ** <0.01; * <0.05. Letters in superscript annotate mean separation within groups. Entries with the same letter are not significantly different using LSD.

Table 6: Agronomic data from larger scale evaluations performed at UC-IREC during harvest year 2022. Thunder was planted in a 0.04ha plot and Lontra was planted in a 0.40ha plot.

Variety	Protein (%)	Plump (>6/64)	Thin (<5/64)	TW (g/L)	Yield (kg/ha)
Thunder	10.8	92.0	4.0	646.2	8002.9
Lontra	11.5	89.5	0.6	639.7	6904.4

Table 7: Micro-malting data from the CCRU for Lontra and Wintmalt from harvest years 2016-2019 at Corvallis. Mean comparisons using years as replicates did not reveal any significant differences among the malting data.

Year	Variety	Protein (%)	Extract (FGDB%)	DP (°ASBC)	AA (20°DU)	FAN (mg/L)	S/T (%)	β-glucan (mg/L)	Color (°SRM)	All-malt Score
2016	Lontra	12.0	83.0	186.0*	62.8	182.0	43.5	55.0	1.7	68.0
	Wintmalt	10.2	81.9	146.0	53.7	201.0*	48.1*	116.0*	1.5	56.0
2017	Lontra	8.5	83.5	108.1	54.4	149.9	49.6*	14.8	1.8	47.0
	Wintmalt	9.7	82.9	126.1	63.5	169.8	45.9	27.7	1.6	44.0
2018	Lontra	11.3	80.3*	146.7	45.6	179.9	50.8*	145.4*	1.7	29.0
	Wintmalt	9.7	81.9	118.3	51.5	162.7	52.2*	136.2*	1.6	40.0
2019	Lontra	11.4	81.7	177.2*	58.2	211.9*	49.2*	28.3	2.0	33.0
	Wintmalt	11.5	79.5*	154.9*	58.7	166.7	40.9	32.4	2.4	27.0
4-yr	*Lontra*	*10.8*	*82.1*	*154.5*	*55.3*	*180.9*	*48.3*	*60.9*	*1.8*	*44.3*
Average	*Wintmalt*	*10.3*	*81.6*	*136.3*	*56.9*	*175.1*	*46.8*	*78.0*	*1.8*	*41.8*
AMBA all-malt	*guidelines*	*≤12.0*	*>81.0*	*110-150*	*40-70*	*140-190*	*38-45*	*<100*	*1.6-2.8*	*Max=70*

*Outside of AMBA guidelines for all-malt brewing. FGDB, fine grind dry-basis; DP, diastatic power; AA, α-Amylase; FAN, free amino nitrogen; S/T, soluble to total protein ratio.

Table 8: Micro-malting data from 2020 crop year comparing Lontra to the malting barley variety Thunder at three locations.

Location	Protein (%)	Extract (FGDB %)	DP (°ASBC)	AA (20°DU)	FAN (mg/L)	S/T (%)	β-glucan (mg/L)	Friability (%)	All-malt Score
Corvallis	10.6	83.2	180*	97.1*	307*	58.3*	54	91.5	36
Pendleton	10.8	86.0	166*	94.5*	289*	56.0*	48	92.7	36
Tulelake	9.0	85.1	117	84.7*	254*	58.9*	37	97.3	42
Line Average	*10.1*	*84.8*	*154**	*92.1**	*283**	*57.7**	*46*	*93.8*	*38*
Corvallis	11.0	84.6	166*	75.4*	240*	50.1*	71	91.5	36
Pendleton	12.0	83.0	164*	70.8*	226*	45.2*	73	87.2	39
Tulelake	10.3	83.8	137	59.3	190	47.1*	45	90.6	47
Line Average	*11.3*	*83.4*	*156*	*68.5*	*219**	*47.5**	*63*	*89.8*	*41*
all-malt guidelines	*≤12.0*	*>81.0*	*110-150*	*40-70*	*140-190*	*38-45*	*<100*	*>80*[α]	*Max=70*

*Outside of AMBA guidelines for all-malt brewing. FGDB, fine grind dry-basis; DP, diastatic power; AA, α-Amylase; FAN, free amino nitrogen; S/T, soluble to total protein ratio.

Friability guideline is not provided by AMBA and an industry recommendation was used in its place (Schoales & Heinrich, 2020).

Malting data was reprinted with permission from Halstead et al. (2022).

Table 9: Mini-malting data of floor malts produced at Admiral Maltings in 2021. Malts were produced to mimic a commercial-type Pale Ale malt.

Line/Variety	Protein (%)	Extract (FGDB %)	DP (°ASBC)	AA (20°DU)	FAN (mg/L)	S/T (%)	β-Glucan (mg/L)	Color (°SRM)	Friability (%)
Lontra-floor	10.3	82.8	111	47.4	194*	50.4*	48	3.3	92.2
Copeland-floor	10.3	79.1*	121	73.6*	219*	56.2*	43	4.1	94.5

*Outside of AMBA guidelines for all-malt brewing. FGDB, fine grind dry-basis; DP, diastatic power; AA, α-Amylase; FAN, free amino nitrogen; S/T, soluble to total protein ratio.