

## **Identifying and Developing Improved Spring Barley Varieties for Montana**

Spring Barley is an important crop in Montana. At first, barley was primarily grown as an animal feed, but more recently malt barley has dominated the state. Barley is an important part of crop rotation in Montana, rotating with sugar beets, wheat and more recently pulse crops. Growers need stable markets for barley, although in recent years barley markets have been anything but stable with increased contracts one year followed by cut contracts the next. The climate is also mirroring that lack of stability, from record production in 2016 to drought and crop failure in 2017, to delayed planting and harvest in 2018 and 2019 with fall rains causing pre-harvest sprout damage. Growers need crops that will perform in a changing environment. The MSU Spring Barley breeding program is working to address these concerns. An important goal of the MSU program is to develop barley that is suitable for new markets providing more opportunities for the growers of Montana. We are developing lines with unique malting attributes so that Montana growers can tap into the craft brewing market. Craft brewers are also interested in Montana made from **Grower to Glass**, which is feasible with the development of the Montana craft malt industry. Malt barley is an example of a value-added market for Montana, where Montanan's can benefit from all steps of the supply chain. Growers not only garner higher revenue by selling grain for malt, but some are also malting their own barley, adding value to their crop. We are breeding barley for other high value markets, including organic food barley with improved nutritional value and highly digestible forage barley for livestock feed. Breeding barley to perform in an ever-changing environment is another goal for the program. We are working to make barley more resilient to heat, drought, acid soils, untimely rains as well as several diseases and pests. The MSU Barley breeding program's primary goal is to provide varieties that will be of economic benefit to Montana Growers.

### **Objectives for 2019**

#### **Continue the barley breeding pipeline**

Table 1 indicates breeding goals of crosses made 2015-2019. We have started incorporating crosses from 2015 back into the germplasm. Traits we are interested in improving are yield and quality stability through extended grain-fill and shorter stature. We are also making crosses to improve resistance to abiotic and biotic stress, including drought tolerance, acid tolerance and tolerance to FHB. For forages, we will increase biomass through later heading and taller stature as well as increasing feed efficiency through improved digestibility. Our food and feed breeding goals include improving nutrition through protein, beta glucans and anthocyanins.

Breeding Goals	2015	2016	2017	2018	2019
High yield, high quality malt and feed	90	87	29	39	9
Heirloom malt			75	90	94
Food	19	21	23		
Forage	12	12	11	14	5
FHB resistance	14	22	13	12	8
Lodging resistance	11	1			
Extended grain-fill	31	12	7		
Spot form of Net Blotch	3	12			
Nematode Resistance	4	10	1		
Stripe Rust			2		4
Beer Stalling	6				
Acid tolerance			20	11	4

**Table 1: Crosses made in the MSU barley breeding program**

**Test most advanced crosses**

The barley breeding pipeline is fully formed and we have new material at every stage. The Tables 2-10 report agronomic data from the Intrastate nursery 2019. We lost the two SARC nurseries due to hail.

Interestingly, new Montana lines are some of the highest yielding lines across all locations probably due to stay green genes. Montana lines also have low protein and high plumps under dryland conditions. Tables 11 – 13 report malt quality data from 3 intrastate nurseries. Blue color indicates lines with adjunct malt quality, yellow indicates lines with craft malt quality and rust indicates lines with unacceptable quality at that location. Tables 14-15 report data from the early yield trials and Table 16 reports malt quality data for one location of the EYT. We also have agronomic and quality data on over 200 lines from a preliminary yield trial (not shown).

We are working to reduce the impact of factors limiting barley production in Montana as follows:

**Heat and drought:** Extended grain-fill lines are reported to be drought and heat resistant, storing more starch in drought conditions than regular grain-fill lines, reducing percent protein, a quality advantage for malting barley. These lines also seem to have different root development that can provide tolerance to drought.

**Acid tolerance:** Low soil pH is a limiting factor in central and eastern Montana. Barley has stunted growth under low pH conditions. We have acquired germplasm noted to be acid tolerant. We tested Montana lines for acid tolerance in 2019. Differences in root development could provide a new source of acid resistance.

**Pre-harvest Sprouting:** In 2014 and 2019 rains during harvest caused some barley to sprout, reducing quality. We are testing lines for dormancy at harvest, and speed of germination during malting. We have found these two important traits are at least somewhat under separate genetic control. If so, we can breed a line that is dormant at harvest, benefiting growers; but also germinates quickly once dormancy is broken, benefiting maltsters.

**Harvest Damage:** Although most of the barley grown in the state has a hull that tightly adheres to the kernel, varieties that are free-threshing can be grown for feed and food. In fact, free threshing barley is preferred as pig feed. However, free-threshing varieties are more sensitive

to damage of the embryo during harvest, which can reduce germination when growing for seed. Genetics as well as cultural practices can help with embryo damage.

**Biotic stress:** Although biotic stress is relatively low in Montana, there are some potential threats we are anticipating in case they become a significant economic liability. New gene combinations are being created for resistance to Fusarium head blight (FHB or scab), the spot form of net blotch, bacterial leaf spot, stripe rust, root lesion nematodes and the wheat stem sawfly. We will continue these efforts in collaboration with other investigators and monitor for potential threats and solutions to include in the program.

New gene combinations to improve yield is a constant goal because growers are paid by the amount they produce. However, quality must also be improved, and stabilized so that growers can make a sale. The MWBC was important in the establishment of the MSU Malt Quality Lab. One of the justifications for the lab is that it would provide more malt quality data points for the breeding program. These data points allow us to test malt quality in more environments allowing us to test for malt stability. They also allow us to test at an earlier generation through methodology we have established, allowing us to improve malt quality more efficiently. No other breeding program in the country is taking advantage of malt data points in this way. Providing our own malting and testing has enabled us to better understand the requirements of a high-quality malt variety. Other breeding goals include adaptation to dryland grain production, increased forage biomass, improved forage digestibility, and improved human food nutrition. The ultimate goal is to support and increase markets for barley in Montana.

Several graduate student projects involve identifying new genes to improve barley. The overarching goal of these projects is to better understand the genetic control over malt quality, forage quality, and drought tolerance. This understanding will be directly applied to improve barley for Montana. Importantly, we now have genotyping data for the drought tolerant population and malt quality population and are in the process of making marker trait associations.

Montana State University Barley Breeding Program's primary mission is to develop new lines that ensure an adequate supply of high-quality malting, feed, forage and food barley, providing growers and the state with important income. Our primary objective is to enhance barley competitiveness by increasing yield and yield stability and reducing risk to growers by improving quality stability. Another objective of the program is to identify, develop and utilize new traits in released varieties that will provide an economic advantage to growers or end-users. Finally by providing lines with new end-uses we hope to provide new markets for Montana Growers.

Table 2: Intrastate Agronomic

Bozeman Dry								
name	yield	test_wt	protein	heading	maturity	height	plump	lodging
	bu/ac	lbs/bu	%	julian	julian	cm	%	%
Bow	139	54.5	11.5	191.3	228.3	90.2	97.5	0
Buzz	140.6	54.4	10.8	187	230.3	81.8	96.8	2
Ellinor	163.5	53.1	10.8	193	231	77.2	97.5	0
Fraser	148.6	53.6	11.4	189.3	228	85.3	98	0
Genie	148.1	55.1	11.9	191	230.3	77	94.3	0
Hockett	119.9	55.2	12.3	187	228	83.8	93	43
Leandra	157.7	53.6	10.8	192.3	228.7	71	97	0
Merit 57	146.7	53.8	11.7	188.3	231.3	83.7	93.6	0
Metcalfe	134.8	55.2	12.6	186.3	226.7	91.7	95.8	8
Odyssey	151.7	54.5	10.6	192.7	230.3	70	96.6	0
Opera	154.1	53.4	10.5	192.3	230	68.3	93.1	0
IK14-8413	145.9	54.8	12	188.3	229.3	80.7	97.3	0
2IM14-8212	146.3	54.2	11.5	186.7	228	80.7	97.5	0
MT090202	151.6	55.6	10.9	189.7	230.7	93.2	96.8	0
MT16M00209	156.7	53.3	11.2	187	229.3	82.5	99.1	0
MT16M00305	143.5	53.9	11.6	187	228.7	84.2	95.6	0
MT16M00406	154.1	53.9	11.2	189	233	89.8	97.9	0
MT16M00407	148.5	53.5	11.8	187	231	94.3	98.3	0
MT16M00408	136.9	53.5	11.9	187.3	231	92	98.8	0
MT16M00504	148.8	54.1	12.2	186.7	229	83.8	98.6	0
MT16M00603	147.1	53.8	11.9	187.7	230.7	89.5	98.3	0
MT16M00610	147.5	55.5	12	185.3	229.7	92	97.4	0
MT16M00707	144.9	56.1	11.6	188	230.3	95.2	98	0
MT16M00709	156.9	54.4	10.7	188	231.7	95.8	97.2	2
MT16M00806	153.6	54.7	12.3	187	229.7	95	97.7	0
MT16M00807	139.9	53.7	11.9	186.7	230.7	87.5	98.2	0
MT16M01204	136.2	54.3	11.9	183	228.7	80.7	97	0
MT16M01405	149.6	55	11.3	187	230	83.7	97.5	0
MT16M01705	121	54.9	11.7	183	225.3	86.2	94.7	12
MT16M01801	167.5	54.8	10.3	188.3	230.7	88.3	96.6	0
MT16M01803	137.8	54.8	11.8	183	228.3	86.8	96.6	0
MT16M01806	146.6	54.9	10.4	187	230.3	90.5	97.9	0
MT16M01819	140	54.6	11.9	185	230.7	84	96.3	0
MT16M01901	143.8	54.7	10.9	186.7	230	83.2	96.9	0
MT16M01902	153.2	53.8	11	186.7	229.7	86.2	96	0
MT16M02003	139.9	54.7	11.2	186.3	226.7	85.2	93.9	0
MT16M02008	134.3	53.5	11.8	186	228	88.7	98.1	0
MT16M02101	130.2	52.1	11	186.7	227	88.5	91.4	52
MT16M02106	128.6	53.6	11.5	187.3	228.7	92.3	95.7	20
MT16M02107	128.8	55.1	12.2	186	225.3	93	94.7	12
MT16M02201	137.8	53.3	11.5	186.7	228.3	85.3	97.9	15
MT16M05403	151.6	55.9	11	189.7	233.7	83	94.8	0
MT16M05610	151	55.4	11.1	190.3	231	86	97.7	0
MT16M05902	134.9	55.4	11.2	182	230.7	83.3	97.2	0
MT16M06110	143.1	54.8	10.8	187	230.7	83.8	96	0
MT16M06404	129.9	55.2	13.1	187.7	229	89.7	97.6	0
MT16M07806	145.1	55.9	11.7	188.7	230	86.5	97.2	0
MT16M09602	129.7	54.8	11.2	185.3	230.7	76.5	96.4	0
MT16M10204	129.9	56	15.8	190.7	227	94.2	91.6	27
GRAND MEAN	143.61973	54.47483	11.5483	187.59184	229.5102	85.7483	96.52177	3.91156
CV	5.0793	0.86083	4.07741	0.34257	0.47503	2.52958	0.7687	223.21895
LSD	14.0914	0.90584	0.90958	1.24137	2.10601	4.18996	1.43324	16.86622



Table 3: Intrastate Agronomic

Bozeman Irr								
name	yield	test_wt	protein	heading	maturity	height	plump	lodging
Bow	104.8	50.1	11.3	191	228.7	98.3	97	2
Buzz	126.1	50.8	10.6	184.3	233.7	85.7	95.7	2
Ellinor	<b>160.1</b>	47.8	10.6	191.3	232.7	78.3	95.3	2
Fraser	123.1	49.6	11.4	190.7	229	96.3	95.6	2
Genie	139.1	50.4	11.6	189.7	227.3	84.7	87.4	15
Hockett	123.6	50.9	11.6	185.7	227	86.3	89.8	58
Leandra	<b>167.3</b>	49	10.8	190.3	229.3	74.7	93.5	12
Merit 57	131.9	48.6	11.7	188	230.7	89.8	88.4	7
Metcalfe	127.1	49.9	11.9	187	228.7	99	90.6	17
Odyssey	136.1	48.7	10.8	191.7	233	74.8	93.3	11
Opera	145.7	48	10.5	191.7	233	73.8	89.6	1
IK14-8413	132.9	49.6	11.5	186.7	228.3	90.3	93.9	5
2IM14-8212	143	48.5	11.6	185.3	227.7	91.2	94.3	7
MT090202	126.5	51.3	11.1	188	233	96.5	94.3	1
MT16M00209	<b>146.7</b>	49.4	10.6	184.3	234	87.2	97.2	8
MT16M00305	125.2	49.7	11.2	184.3	231.7	92.8	94.4	15
MT16M00406	<b>149</b>	50.7	11	188	235.3	98.3	96.6	1
MT16M00407	117.3	50.9	11.4	184.7	234.3	97	97	3
MT16M00408	131.4	50.7	11.2	187	237.3	97.2	98.1	0
MT16M00504	124.9	51.1	11.6	184.7	235.3	89	98.3	2
MT16M00603	134.8	50.2	11.3	185.7	233.7	90	96.8	1
MT16M00610	126.5	51.3	11.6	183	233.7	96.3	97.4	7
MT16M00707	118.9	52.2	11	186.3	231	99.7	96.1	8
MT16M00709	122.5	51.7	10.8	186.3	233.3	102.5	94.7	13
MT16M00806	114.5	51.2	12	185.3	232	101.2	96.1	8
MT16M00807	130.5	49.8	11.4	183.3	235.3	94.2	96.9	1
MT16M01204	121.6	49.9	11.1	182	236	77.3	96.2	3
MT16M01405	138.1	51.8	10.9	184.3	234.7	89.3	96.8	0
MT16M01705	106.6	48.2	11.3	182	226	88.3	90.2	43
MT16M01801	123.2	49.8	10.1	187	233.3	94.8	93.2	8
MT16M01803	121.1	51.1	11.1	183	231.7	90.5	94.8	8
MT16M01806	121.8	50.7	10.1	185.3	233.7	97.5	91.9	15
MT16M01819	128.7	51.9	11.2	182.7	234	91.8	93.1	0
MT16M01901	<b>148.4</b>	50.8	10.5	185	234	89.8	95.8	0
MT16M01902	119.1	48.6	10.8	184.7	232.3	94.5	92.8	6
MT16M02003	108.8	49.3	10.9	184	229.7	90.7	92.5	18
MT16M02008	126.9	50.7	11.2	183	231.7	95.8	96.5	0
MT16M02101	106	45.3	10.8	183	227.3	91.2	85.1	35
MT16M02106	118.8	48.1	10.9	186.7	231	90.7	91.2	32
MT16M02107	115.7	49.8	11.3	184	227.3	92	90.2	55
MT16M02201	112.6	49	11.2	185	230.7	90.3	95.4	12
MT16M05403	136	51.5	11.4	189	236.7	94.7	91	2
MT16M05610	140.3	51	10.8	189.3	231.7	96.3	95.1	0
MT16M05902	138.7	49.4	10.4	179.7	234.3	88.7	93.9	3
MT16M06110	105.3	50.9	10.4	185.3	232	92.7	93.3	0
MT16M06404	123.8	51.8	12.2	186	228	100	94.4	15
MT16M07806	110.6	50.6	10.6	186	229	92.5	94.6	15
MT16M09602	122.9	50.1	10.8	182.3	233	83.2	94.2	6
MT16M10204	107.5	51.6	9.2	190.3	227.7	98.2	85.6	43
GRAND MEAN	127.18776	50.07891	11.04694	186	231.72789	91.34694	93.79932	10.82993
CV	8.33576	1.29775	2.09507	0.45026	0.69168	2.73378	1.722	85.81622
LSD	20.47985	1.2554	0.44723	1.61777	3.09613	4.82384	3.1201	17.95276

Table 4: Intrastate Agronomic

CONRAD DRY							
name	yield	test_wt	protein	heading	height	plump	lodging
Bow	79.4	52.8	12.2	184	69.4	92.8	6
Buzz	78.9	54.3	11.9	178	68.2	95.3	3
Ellinor	<b>107.7</b>	53.3	12.4	183	63.9	93.7	4
Fraser	84.6	50.6	13	183.3	66.1	80.7	5
Genie	<b>92</b>	53.7	14.4	183.3	61.4	67.5	2
Hockett	<b>92.8</b>	55.5	13.1	180.3	69	92.9	8
Leandra	<b>102.7</b>	52.8	13.3	182.7	53.8	87.3	2
Merit 57	<b>91.9</b>	49.7	14.1	183.3	74.1	67.9	5
Metcalfe	85.3	53.8	13.1	180.7	73.7	92.2	7
Odyssey	<b>96.8</b>	55	12.9	183.3	58.9	96.5	4
Opera	<b>99.6</b>	52.7	11.9	183	54.2	86.4	3
IK14-8413	<b>88.2</b>	52.4	12.3	183	69.4	93	7
2IM14-8212	<b>108.3</b>	53.5	13.1	180.7	69.4	92.4	5
MT090202	<b>95.8</b>	56.3	12.9	182.7	75.3	95.5	3
MT16M00209	<b>91.6</b>	53.6	12.3	177.7	67.7	97.3	4
MT16M00305	86.3	53.8	13.2	178	66	94.2	3
MT16M00406	<b>94.2</b>	53.4	11.7	181.3	73.7	96.3	4
MT16M00407	85.3	35.4	8.3	178.3	70.3	65.2	3
MT16M00408	83.5	53.6	12.5	180.7	71.5	97.1	2
MT16M00504	<b>88.6</b>	53.9	13	177	68.1	95.6	3
MT16M00603	<b>89.8</b>	52.2	11.9	177.3	72	97.1	3
MT16M00610	<b>98.8</b>	56.5	13.1	176.3	75.8	97.7	2
MT16M00707	<b>90.2</b>	56	12.1	180.7	74.5	94.3	5
MT16M00709	<b>88.1</b>	54.1	12.1	182	77	87	7
MT16M00806	<b>94.9</b>	55.3	13.2	179.3	75.8	94.6	7
MT16M00807	84.1	55.2	12.7	176.3	71.1	98	2
MT16M01204	84.2	54	12.4	174	64.4	96.7	3
MT16M01405	<b>93.9</b>	56.1	12.5	177.3	66.5	97.6	5
MT16M01705	<b>95.3</b>	59.4	12.8	175	71.1	92	6
MT16M01801	<b>103.1</b>	55.4	12	181.3	75.8	95.7	2
MT16M01803	<b>94.8</b>	56.3	12.6	176.7	71.1	95.4	3
MT16M01806	78.6	55	11.6	181	67.7	96.2	3
MT16M01819	87.6	54.9	12.7	175.7	64.8	97	2
MT16M01901	86.2	55.8	12	180.3	65.6	95.7	2
MT16M01902	<b>99.1</b>	54.2	12.9	178.3	68.1	93.7	4
MT16M02003	<b>103.7</b>	56.1	12.3	177.7	65.2	92.9	3
MT16M02008	78.3	54.5	13	177	68.6	96.8	2
MT16M02101	<b>100.4</b>	54.5	12.3	176.3	71.6	90.9	4
MT16M02106	<b>98.6</b>	36.1	7.6	178.7	74.5	62.8	5
MT16M02107	<b>89.5</b>	55.2	12.7	176.7	69	92.1	8
MT16M02201	<b>93.3</b>	54	13	178.7	66.5	95.1	3
MT16M05403	<b>93.6</b>	54.4	11.4	184.3	66.9	87.1	4
MT16M05610	<b>91.6</b>	56.1	13	182.3	72	88.2	3
MT16M05902	82.3	56.2	12.6	174	66	94.9	5
MT16M06110	<b>95</b>	56.3	12.3	179.3	68.6	95.6	3
MT16M06404	<b>96.2</b>	55.9	13.1	181	72	94.7	5
MT16M07806	<b>90.7</b>	56.1	12.7	181.7	71.1	92.9	3
MT16M09602	80.8	55.8	13.1	175.3	63.1	95.2	4
MT16M10204	<b>92.2</b>	53.8	0	182.3	76.6	77.1	4
GRAND MEAN	91.6	53.78231	12.1898	179.61905	68.91905	91.11769	3.95238
CV	11.51094	11.70777	12.80844	0.56453	5.45568	13.76411	42.21061
LSD	20.37135	12.16326	3.01598	1.95873	7.26314	24.2263	3.22268



Table 5: Intrastate Agronomic

CONRAD IRR							
name	yield bu/ac	test_wt lb/bu	protein %	heading julian	height cm	plump %	lodging %
Bow	107.1	52.2	12.3	184	83	95.1	13
Buzz	108.5	52.2	11.6	178	72	92.4	18
Ellinor	<b>139.6</b>	51.3	11.8	183	62.7	96.4	18
Fraser	109.6	50.1	12.3	183.3	67.8	88.9	38
Genie	<b>125.7</b>	51.4	12.9	183.3	69	81.6	57
Hockett	97.7	51.9	12.8	180.3	64.4	86.3	72
Leandra	<b>125.1</b>	51.5	12.1	182.7	57.6	95.8	32
Merit 57	100.2	51.3	12.3	183.3	79.2	88.7	12
Metcalfe	101	53.4	13.6	180.7	76.2	85.3	53
Odyssey	<b>124.3</b>	51.5	12.2	183.3	55	89.3	37
Opera	<b>134.7</b>	50.3	11.8	183	60.1	90.4	7
IK14-8413	110	52.8	13.1	183	74.5	94.8	15
2IM14-8212	<b>134.3</b>	52.3	11.7	180.7	78.3	96	33
MT090202	106.5	53.5	12.1	182.7	82.6	93.7	6
MT16M00209	<b>131.7</b>	52.4	11.5	177.7	77.9	98	12
MT16M00305	115.4	51.1	8.1	178	64.4	93.6	35
MT16M00406	<b>141.2</b>	53.6	11.6	181.3	85.1	96.5	15
MT16M00407	116.8	52.4	12.4	178.3	80.9	96.4	27
MT16M00408	118	53	11.9	180.7	82.1	96.7	22
MT16M00504	114.4	52.5	12.3	177	76.2	96.7	32
MT16M00603	121.8	52.4	12.4	177.3	81.3	96.5	8
MT16M00610	<b>129.9</b>	53.1	12	176.3	72	95.5	40
MT16M00707	121.9	53	11.7	180.7	83.8	95.1	40
MT16M00709	112.8	51.7	11.2	182	69.9	92	68
MT16M00806	99.1	53.1	12.4	179.3	80	95.1	12
MT16M00807	120.2	53.4	12.2	176.3	81.3	97.4	7
MT16M01204	119.8	53	12.1	174	74.1	97.2	12
MT16M01405	<b>128.8</b>	52.9	11.9	177.3	73.7	95.7	36
MT16M01705	98.6	52.6	12.2	175	66	90.5	67
MT16M01801	<b>129.7</b>	53.5	11.2	181.3	85.5	95.6	16
MT16M01803	116.4	53.6	11.8	176.7	82.1	93.9	12
MT16M01806	115.1	51.6	11.1	181	70.3	91.4	57
MT16M01819	<b>122.7</b>	53	12.4	175.7	72.4	96.2	26
MT16M01901	<b>137.9</b>	54.2	11.1	180.3	81.7	96.7	8
MT16M01902	<b>146.8</b>	52	11.5	178.3	81.7	92.7	23
MT16M02003	<b>135.6</b>	54.2	11.1	177.7	77.1	95.3	12
MT16M02008	120.8	52.7	12.1	177	83.8	96.1	6
MT16M02101	117.5	49.6	11.5	176.3	60.6	84.4	69
MT16M02106	111.6	52.7	11.5	178.7	72	94.6	47
MT16M02107	111.2	53.7	13	176.7	70.3	93.2	43
MT16M02201	113.4	49.6	11.9	178.7	68.6	90.2	67
MT16M05403	117.2	53.6	12.3	184.3	68.6	86.1	32
MT16M05610	<b>122.8</b>	52.3	11.9	182.3	83.8	95.5	27
MT16M05902	112.9	54.1	11.3	174	74.1	96.6	9
MT16M06110	<b>123.6</b>	53	11.1	179.3	74.1	93.7	27
MT16M06404	111.9	53.5	13.3	181	76.6	94.8	43
MT16M07806	115.5	53.7	12.1	181.7	77.1	95.4	31
MT16M09602	111.1	54.4	12.5	175.3	71.6	94.5	27
MT16M10204	106.2	52.5	10.3	182.3	66.9	78	69
GRAND MEAN	118.66259	52.51497	11.90204	179.61905	74.07279	93.11701	30.48299
CV	10.6947	2.10023	14.98837	0.56453	10.22005	3.89755	75.87663
LSD	24.51862	2.13052	3.44597	1.95873	14.62338	7.01062	44.67883

Table 6: Intrastate Agronomic

Havre Dry						
name	yield bu/ac	test_wt lb/bu	heading julian	maturity julian	height cm	plump %
Bow	87.9	51.4	177.3	204.3	75.8	90.6
Buzz	82	52.1	176.3	202.3	63.7	93.9
Ellinor	84.2	49.2	178.3	205.7	59.9	91.1
Fraser	76.5	50.7	177.3	203.7	64.6	93.5
Genie	79.8	52	177.3	203.3	60.3	84.8
Hockett	74.1	54.1	176.7	202.7	64.7	97.6
Leandra	87.1	50	177.3	203.7	58	95.4
Merit 57	83.2	49.5	176.7	204.7	79.2	84.9
Metcalfe	78	53.4	175	203.7	68.5	95.4
Odyssey	97.5	51.6	179	205.3	58.5	93.5
Opera	101.1	50.8	177.3	205	58	92.2
IK14-8413	93	52.2	173.3	203.3	66.8	95.4
2IM14-8212	98.1	51.9	175	203.3	67.9	94.1
MT090202	87.4	52.1	175.7	205.3	79.6	90.3
MT16M00209	85.4	49.8	175	203	65.9	98.3
MT16M00305	88.6	50	174.3	204	68.3	91.1
MT16M00406	84.9	50	176.3	206	74.3	91.8
MT16M00407	88	50.7	172.3	203.7	69.1	95.8
MT16M00408	77.2	49.4	175.3	206.3	77.6	95.5
MT16M00504	84	51.4	173.7	205.3	66.2	96.1
MT16M00603	92.6	50.5	174.7	205	71.1	95.8
MT16M00610	85.7	52.8	170.3	203.7	67.8	94.6
MT16M00707	82.1	52.6	174.3	204.3	79.9	94.2
MT16M00709	93.2	51.2	174	204.3	82.4	90.3
MT16M00806	81.2	51.8	173.7	203.7	72.9	95.6
MT16M00807	82.8	50.3	174.7	204	70.1	96.2
MT16M01204	88	50.3	169	207	60.9	93.4
MT16M01405	85.2	51.4	174.3	205.7	60.4	92.8
MT16M01705	85.1	52.5	170.3	204	69.6	93.4
MT16M01801	88.9	51.5	173.3	204.3	73.9	92.6
MT16M01803	75.5	52.9	174.7	203.7	67.6	95.6
MT16M01806	81.1	52.2	174.3	205	74	93.6
MT16M01819	86.3	52	174.7	204.7	71.2	94.1
MT16M01901	76	51.5	175.3	204	65.5	88.8
MT16M01902	93.2	50.2	172.7	205.3	68.2	90.6
MT16M02003	98	52	174	203.7	62.4	90.4
MT16M02008	89.2	51.4	172.3	204.7	70.7	96.2
MT16M02101	91.4	50.7	170.7	203.3	69.7	92.9
MT16M02106	94.4	52.5	171.7	203	73.7	94.9
MT16M02107	87	53.2	170.3	202.7	68.6	91.7
MT16M02201	91.1	50.3	173.7	204.7	67.2	96.4
MT16M05403	82.8	52.6	176.3	208.3	71	89.9
MT16M05610	79.7	51.3	176	205.3	66.8	94.2
MT16M05902	81.9	53.4	168	204.7	68.3	93.8
MT16M06110	86.4	52.1	173.3	205.3	67.9	90.6
MT16M06404	74.9	53.2	175.7	203.7	73.7	95.8
MT16M07806	79	53.1	177	203.7	73.5	95.1
MT16M09602	80.7	52.4	175.3	203	58.5	91.6
MT16M10204	83.5	53.6	178	205.7	84.8	86.6
GRAND MEAN	85.60612	51.59388	174.53741	204.38776	68.96599	93.13061
CV	6.05629	0.87252	0.96436	0.73538	4.48181	2.15905
LSD	10.01492	0.86958	3.25135	2.90336	5.97069	3.88411



Table 7: Intrastate Agronomic

Creston								
name	yield bu/ac	test_wt lbs/bu	protein %	heading julian	maturity julian	height cm	plump %	lodging scale 1-5
Bow	150.6	54.7	11.6	190	216.7	90.7	99.4	0
Buzz	158.8	53.9	11.5	182.7	220.3	84.2	98.6	0
Ellinor	<b>175.9</b>	53.7	11.3	194	227	73.7	99.2	0
Fraser	147.5	54	11.6	193	218	81.5	99.2	0
Genie	158	54.9	11.4	196	218	72.5	97.7	0
Hockett	159.7	56.1	12.4	184.7	216.7	90.7	97.4	1
Leandra	<b>190.1</b>	54	11.4	196	226	67	99.2	0
Merit 57	<b>170.3</b>	54.8	10.8	188	221	87.7	98.1	0
Metcalfe	157	56	12.2	186.3	216.7	94.3	97.7	1
Odyssey	<b>175.7</b>	54.3	10.8	196	226	70	98.9	0
Opera	<b>182.5</b>	54.3	10.6	196	226	69.7	97.7	0
IK14-8413	162	54.9	12	192	218	81	98.9	0
2IM14-8212	157	53.8	11.1	192	216.7	80.8	99.2	0
MT090202	166.6	55	11.4	190	225.3	92.7	98.8	0
MT16M00209	158.5	54.5	11.1	188	218	78.5	99.3	0
MT16M00305	161	54.2	11.8	186	218	86.5	98	0
MT16M00406	<b>176</b>	54.3	11.5	190	228	91.7	98.8	0
MT16M00407	166	54.9	12.3	179	225	92.7	99.1	0
MT16M00408	140.2	53.2	12	183.3	222.7	85.8	98.9	0
MT16M00504	157.6	55.3	12.5	179.3	216.7	84.8	99.3	0
MT16M00603	139.5	54.3	12.2	192	226	85	99.1	0
MT16M00610	161.8	55.9	12.4	179.3	217.3	89.8	98.9	0
MT16M00707	165.3	55.7	11.5	185.3	218	93.3	98.8	0
MT16M00709	<b>169.2</b>	55.2	10.7	188	226	101	98.9	0
MT16M00806	<b>174.4</b>	55.5	12.4	190	223.3	97.8	95.9	0
MT16M00807	153.3	54.7	11.2	184.7	225.3	90.5	99.3	0
MT16M01204	155.7	54.2	12.1	179.3	221.7	81	99.4	0
MT16M01405	164.3	54.4	11.9	185.3	221.7	86.8	99.3	0
MT16M01705	138	55.5	11.8	177.7	212.7	88.7	97.3	4
MT16M01801	<b>168.2</b>	54.6	10.9	186	223.7	94.2	99	0
MT16M01803	154.3	55.5	11.7	185.7	218	87.5	99	0
MT16M01806	160.8	55.4	10.6	180	221	88	99.2	0
MT16M01819	153.5	55	12.4	179.3	222.7	79.8	98.5	0
MT16M01901	155.5	54.7	11.3	181	224.3	86.8	99.1	0
MT16M01902	<b>177.6</b>	55.2	11.6	180	218	85.7	97.8	0
MT16M02003	<b>167.9</b>	55.1	11.2	180.3	219	85.2	97.9	0
MT16M02008	149.2	54.4	11.5	177.7	218	89.3	99	0
MT16M02101	<b>170.7</b>	54.6	11.3	178.7	216.7	92.3	95.8	4
MT16M02106	<b>169.1</b>	54.9	11.5	187.3	216.7	90.5	98.3	2
MT16M02107	154	56	12.3	179.3	212	91	96.8	2
MT16M02201	165.9	54.8	11.9	182	220	85.3	98.4	1
MT16M05403	<b>172.8</b>	56.3	11.1	193	228	86.7	97	0
MT16M05610	156.7	55.1	11.4	192	224.3	91.7	99.3	0
MT16M05902	140.4	55.8	11.5	176.3	228	78	98.5	0
MT16M06110	162.5	54.5	11.1	185.3	225	80.5	98.8	0
MT16M06404	158.6	55.7	13.4	189	218.7	91.7	99.2	0
MT16M07806	156	56	11.7	190	218	87.8	99	0
MT16M09602	144.7	55.1	11.4	180.7	215.3	76.3	99.3	0
MT16M10204	158.5	56.4	0	190	218	96.8	97.3	1
GRAND MEAN	161.0102	54.92517	11.36871	186.07483	220.77551	86.03061	104.64014	0.34694
CV	7.46591	0.77344	2.82809	1.60273	1.22994	5.78718	70.18446	244.9529
LSD	23.22054	0.82061	0.62107	5.76082	5.24531	9.61737	141.86504	1.64162

Table 8: Intrastate Agronomic

Moccasin Dry						
name	yield	test_wt	protein	heading	height	plump
	bu/ac	lb/bu	%	julian	cm	%
Bow	55.5	54.1	9.8	189.7	67.7	90
Buzz	<b>64.6</b>	54.7	9.7	185	66.1	91.2
Ellinor	<b>70.2</b>	52.6	8.7	192	56.7	79.3
Fraser	58.8	53.4	9.8	189.3	58.4	81.3
Genie	<b>62.6</b>	54.6	9.2	193.7	55	82.7
Hockett	46	55.9	9.6	187.7	58.4	93.6
Leandra	<b>62.5</b>	54.8	9.6	193.7	46.6	92.9
Merit 57	<b>62.4</b>	52.8	10.4	190	65.2	71.5
Metcalfe	<b>60.6</b>	54.8	10.4	188	60.9	82.9
Odyssey	<b>63.5</b>	52.9	9.5	194	55.9	74.3
Opera	54.2	51.8	9.1	193.7	54.2	62.7
IK14-8413	<b>70.8</b>	53.7	10	188.7	66	87
2IM14-8212	<b>67.1</b>	53.4	9.6	187.7	61.8	90.1
MT090202	<b>60.6</b>	54.8	9.9	187.7	70.3	89.5
MT16M00209	55.9	54.6	9.1	185.3	66	98
MT16M00305	58.3	53.5	9.8	185.3	58.4	90.9
MT16M00406	50.4	54.7	8.4	189	70.3	96.2
MT16M00407	49.4	55.3	9.4	184.7	66.9	93
MT16M00408	39.2	54.1	10.3	186.7	71.1	95.8
MT16M00504	<b>75.5</b>	55.8	10	184	72	96.8
MT16M00603	52.8	54.6	9.5	185.7	60.1	93.9
MT16M00610	<b>63.2</b>	56	9.6	184	64.3	91
MT16M00707	<b>62.1</b>	56.6	9	187	68.6	90.9
MT16M00709	<b>69</b>	56.2	9	184.7	73.7	85.7
MT16M00806	<b>60.1</b>	56	9.3	185.7	70.3	96.2
MT16M00807	51.3	55.1	9.9	186	67.7	96.8
MT16M01204	52.2	54.6	9.4	184.3	65.2	92.2
MT16M01405	<b>64</b>	53.8	9.5	185.3	61	96.1
MT16M01705	<b>63.3</b>	55.4	9.7	184	58.4	90.2
MT16M01801	<b>60</b>	54.4	8.8	187.3	69.4	88.3
MT16M01803	51.9	54.9	9.4	184.7	60.1	89.5
MT16M01806	58.1	55.2	8.5	185.7	66.9	94.5
MT16M01819	<b>60</b>	56.7	10.5	184	60.1	95.2
MT16M01901	<b>62</b>	54.2	9.5	184.7	66	91.5
MT16M01902	58.1	54.7	9.6	184.7	57.6	81.1
MT16M02003	<b>68.6</b>	54.8	9.4	185.3	56.7	83.8
MT16M02008	56.9	54.5	9.7	184	64.3	88.8
MT16M02101	54.8	54.8	8.5	185.7	61.8	83.6
MT16M02106	59.2	55.5	8.6	185.3	67.7	82.7
MT16M02107	<b>60.2</b>	56.8	9.5	184.3	62.6	87.4
MT16M02201	57.7	57.5	10	186	62.7	89.7
MT16M05403	53.1	55	8.9	189	62.7	82.8
MT16M05610	58.8	54.7	9.1	189.3	62.6	94
MT16M05902	<b>61.4</b>	56.6	9.4	183.7	64.4	93.1
MT16M06110	50.5	55.5	8.9	185.7	57.6	93.5
MT16M06404	<b>60</b>	54.4	9.5	186.7	61.8	94.5
MT16M07806	<b>60.4</b>	56	9.9	188	63.5	94.3
MT16M09602	<b>61.1</b>	55.6	9.6	185.3	56.8	95.2
MT16M10204	<b>63.3</b>	56.3	16.4	188.7	72	82.7
GRAND MEAN	59.23197	54.86939	9.61837	186.94558	63.14898	88.95578
CV	13.95059	1.72153	7.31007	0.38536	6.29785	4.65449
LSD	15.96192	1.82466	1.35843	1.39161	7.68237	7.99801



Table 9: Intrastate Agronomic

Sidney dry							
name	yield bu/ac	heading julian	height cm	plump %	lodging %	severity % Mixture	incidence leaf disease
Bow	129.5	175.7	79.3	97.8	0	18.33	97.78
Buzz	126.1	171.7	71	96.7	0	29.28	100
Ellinor	136.3	175.3	63.3	95.9	0	21.94	100
Fraser	129.4	172.3	70.7	98.3	0	24.17	97.78
Genie	135.2	173.3	63.7	91.7	37	29.17	96.67
Hockett	127	172	71.7	96	7	34.78	100
Leandra	147.8	176	61.3	96.4	0	23.22	98.89
Merit 57	140.4	174.7	79.3	94.4	0	27.78	92.22
Metcalfe	132	172	74.7	95.4	7	40.94	100
Odyssey	147.4	174.7	63	95.4	43	30.28	98.89
Opera	135.8	176.3	59.7	92.8	33	22.72	100
IK14-8413	139.6	172	75.7	96.9	0	13.67	98.89
2IM14-8212	132.1	171.3	71	96.7	3	44.06	96.67
MT090202	123.7	173	72	95.2	0	29.83	97.78
MT16M00209	141.6	169.3	74	99	0	23.34	100
MT16M00305	122.4	169	67	95.3	17	23.83	98.89
MT16M00406	141.9	174.3	77	97.8	0	26.61	100
MT16M00407	114.8	170.7	75	98.4	0	39.02	100
MT16M00408	116.4	172	78.7	99.2	0	23.44	97.78
MT16M00504	130.5	169	77.3	98.5	0	17.44	98.89
MT16M00603	144	170.7	69.7	98.4	0	24.5	100
MT16M00610	112.6	168.7	73.3	98.2	0	14.72	97.78
MT16M00707	128.9	173	81.3	97.8	0	22.22	94.44
MT16M00709	135.9	171.7	78.7	97.6	0	16.17	91.11
MT16M00806	130.8	171.7	74.7	97	3	32.68	100
MT16M00807	126.8	169	79	99	0	24.17	100
MT16M01204	110.4	168.3	67.3	97.3	0	40.83	100
MT16M01405	122.6	170	73	98.2	0	27	100
MT16M01705	119.4	168	74.7	95.4	60	32.89	100
MT16M01801	131.9	173.3	79.3	93.4	23	25	98.89
MT16M01803	121.4	168.7	70.3	95.5	0	35.56	100
MT16M01806	127	171.3	76.3	95.1	0	23.69	98.89
MT16M01819	113.5	168.7	72.7	98.5	0	32.89	100
MT16M01901	115.5	170.7	68.7	98.1	0	20.45	86.67
MT16M01902	111.5	170	79	91.4	90	27	98.89
MT16M02003	108.9	171	69.7	93.7	27	50.39	100
MT16M02008	113.5	169.3	78.3	99.3	0	47.11	100
MT16M02101	131.1	169	74	93.2	0	21.22	100
MT16M02106	113.9	169.7	75	95.7	3	20.94	98.89
MT16M02107	121.4	169	74.7	97	0	51.44	100
MT16M02201	136.3	169	71.7	97.4	0	34.89	100
MT16M05403	127.6	175.7	75.7	93.3	3	27.61	100
MT16M05610	118.9	175.3	73.7	96.1	0	44.39	100
MT16M05902	110	168	68.7	98	0	24.61	100
MT16M06110	126.9	171.7	74.7	95.8	0	30.33	100
MT16M06404	111.2	172.3	71.3	98.4	3	30.83	100
MT16M07806	133.7	174.3	76.3	97.6	0	19.39	96.67
MT16M09602	127.1	169	65.3	96.7	0	39.56	100
MT16M10204	111.4	174.3	85	91.2	100	18.22	96.67
GRAND MEAN	126.40272	171.55102	73.0068	96.37075	9.38776	28.66442	98.57163
CV	9.13035	0.54606	5.8305	1.14205	161.08068	62.15052	4.72584
LSD	22.29359	1.80956	8.22253	2.12602	29.21066	34.41312	8.99843



Table 10: Intrastate Agronomic

Sidney irr							
name	yield bu/ac	test_wt lb/bu	protein %	heading julian	height cm	plump %	lodging %
Bow	158.6	50.8	13	181	86	93.8	38
MT124112	146.6	51.2	12.2	172.3	78.7	96.2	7
Ellinor	144.4	46.7	12.7	180.7	74.3	89.8	65
Fraser	143.1	49.7	12.8	181	86	92.6	53
Genie	149.5	49.8	13.4	177	67.3	75.6	77
Hockett	129	51.2	13.1	174	70.7	87.4	77
Leandra	97.9	31.9	8.5	117	44.3	60.8	42
Merit 57	130.1	49.6	13.4	181.7	83	84.7	33
Metcalfe	148.4	52.6	13.9	177.3	78.3	93.4	38
Odyssey	144.2	46.5	12.7	178.3	72.3	88.8	68
Opera	143.9	45.6	12.1	181.7	70.7	84.9	85
IK14-8413	135.9	50.3	13.4	178	81.7	89.1	45
2IM14-8212	157.4	34.5	8.3	176.8	81.6	64.8	7
MT090202	148.3	52.4	12.1	177.7	85.3	94.1	13
MT16M00209	169.3	33.4	8.3	174.8	81.6	64.7	1
MT16M00305	148.1	33.2	9	172.3	81.6	62.4	2
MT16M00406	181.7	34.5	8.1	178.3	78.6	64.9	1
MT16M00407	157.1	51	13	171.7	87.3	97.8	3
MT16M00408	154.9	49.9	13.3	174.7	83.7	97.9	0
MT16M00504	112.9	33.6	8	114.7	49.7	64.6	0
MT16M00603	158.1	50.5	13	171	72.3	98.3	0
MT16M00610	160.3	52.4	12.8	169.3	79.7	96.5	0
MT16M00707	163.2	52.3	12.5	176.7	84	95.9	3
MT16M00709	155.2	51.2	11.8	175	85.7	94.1	33
MT16M00806	108.8	34.5	8.7	116.7	56.7	64.3	3
MT16M00807	156.2	50.2	12.2	175	86.3	98.5	0
MT16M01204	152.5	50.8	12.6	173	76	97.5	0
MT16M01405	156.7	51.8	12.3	171	77.7	97.5	2
MT16M01705	129	51.8	12.8	169	76	94.5	47
MT16M01801	165.5	50.8	12	177.3	83.7	95	43
MT16M01803	153.1	52.7	12.5	172.3	76.7	95.5	25
MT16M01806	155	50.5	12.1	175.7	86.3	93.2	40
MT16M01819	152.4	51	13	170.7	78	95.6	3
MT16M01901	165.6	51.4	12.4	174	79.7	97.7	0
MT16M01902	168.4	34.3	8.2	170.8	74.1	64.7	3
MT16M02003	164.7	51.9	12.3	172.7	71.3	95.7	12
MT16M02008	158.9	51.4	12.5	172	84.3	97.8	0
MT16M02101	139.6	32.7	12.1	174	74.7	90.2	73
MT16M02106	151.6	50	12.4	174	80.3	93.1	68
MT16M02107	147.7	52.1	13.6	171.7	80.3	92.8	62
MT16M02201	127.6	49.2	12.5	173	69.7	95.4	30
MT16M05403	147.8	51.3	12.7	180	84	88.1	40
MT16M05610	140.6	49.6	12.8	177	88	92.9	38
MT16M05902	147.6	34.3	8.4	172.3	73.6	65.7	0
MT16M06110	162.6	34.4	8.1	175.8	88.1	64.9	1
MT16M06404	135.6	52.3	14.3	177.7	83.3	93.4	67
MT16M07806	148.6	51.8	12.7	177.7	82	94.2	52
MT16M09602	151	52	12.5	174	66.3	96.5	3
MT16M10204	118.1	0	0	177.7	80.7	75.3	95
GRAND MEAN	147.82313	45.86259	11.57483	171.58231	77.59592	87.00408	28.58503
CV	17.13103	29.14289	28.06497	14.74242	16.21066	28.04598	78.79364
LSD	48.98255	25.81828	6.27502	48.92793	24.33073	47.13531	43.53149

Table 11: Intrastate Quality

2019 Bozeman Intrastate Dry Malt Quality								
name	Extract	Soluble protein	Soluble/Total protein	Diastatic Power	alpha amylase	beta glucan	fan	malt protein
	%	%	%	°ASBC	20°DU	ppm	ppm	%
2IM14-8212	80.6	6	0.5	188.3	92.5	67	285	11.55
Bow	82	6.4	0.5	142.1	97.6	30.5	268	11.68
Ellinor	80.8	4.5	0.4	121.6	60	176.8	182	11.4
Fraser	81.1	6	0.5	166.9	86.7	31.7	245	11.91
Genie	90.6	6.3	0.5	190.8	101.8	70.9	264	13.08
Hockett	79.5	4.9	0.4	196.8	66.8	290.7	213	12.71
IK14-8413	81.1	6.1	0.5	205	102	44.1	256	11.99
Leandra	80.5	5	0.4	145	77.3	61.6	201	11.58
Merit 57	82.2	5.7	0.5	183.6	114.6	42.5	285	12.13
Metcalfe	81.1	6.1	0.5	193.6	89.8	43.5	262	12.56
MT090202	78.9	4.6	0.4	180.4	58.7	132.3	187	11.57
MT124112	81.6	5.4	0.5	162.6	97.9	86.4	242	11.17
MT16M00209	78.8	4.7	0.4	120.5	49.7	389.5	193	12.07
MT16M00305	80	5.4	0.5	122.4	82.1	122.4	249	12.22
MT16M00406	79.6	5.1	0.5	178.7	61.2	251.3	219	11.7
MT16M00407	78.8	4.6	0.4	144.5	44.1	299.9	191	12.54
MT16M00408	79.1	5.4	0.5	145	46.6	325	233	12.05
MT16M00504	78.7	4.8	0.4	152.7	44.4	529.2	197	12.54
MT16M00603	79.7	5.8	0.5	174.9	56.5	316.1	223	12.31
MT16M00610	79.9	5.1	0.4	173.3	63.9	319.8	196	12.52
MT16M00707	80.6	5.1	0.4	171.9	65.8	173.7	200	12.1
MT16M00709	78.1	4	0.4	132.7	45.7	494.2	150	11.69
MT16M00806	78.7	4.5	0.4	138	46.6	305	171	12.77
MT16M00807	79.5	5.1	0.4	150.8	46.5	277.5	219	12.37
MT16M01204	77.7	4.8	0.4	209.4	41.5	282.8	192	12.18
MT16M01405	78.6	4.1	0.4	140.8	47	280.5	152	11.79
MT16M01705	80.9	5.6	0.4	189.4	77.6	134.2	266	11.95
MT16M01801	81.7	5.1	0.5	180.6	71.5	271.3	224	10.89
MT16M01803	79.2	4.6	0.4	189.8	54.6	324.4	185	12.14
MT16M01806	79.6	4.4	0.4	151.5	48.4	317.3	163	11.03
MT16M01819	78.7	4.4	0.4	164.6	43.2	365.3	164	12.39
MT16M01901	80.5	5.4	0.5	182.4	61.9	222.3	221	11.38
MT16M01902	80.2	4.8	0.4	180	63.7	191.4	213	11.55
MT16M02003	80.5	4.6	0.4	208.2	60	286.3	199	11.62
MT16M02008	79.2	4.8	0.4	177.7	42.1	123	207	12.67
MT16M02101	81.7	5.5	0.5	167.9	76.1	156.2	229	11.64
MT16M02106	80.5	4.8	0.4	181.2	75.9	358.4	201	11.72
MT16M02107	79.4	5.3	0.4	203.8	72.4	207	229	12.5
MT16M02201	83.5	5.8	0.5	159.4	61.2	242.5	239	12.08
MT16M05403	80.1	5.3	0.5	190.4	81.3	225.9	206	11.55
MT16M05610	81.9	5.8	0.5	207.2	97.5	117.1	263	11.4
MT16M05902	79.1	4.6	0.4	161.3	47.8	346.7	168	12
MT16M06110	80.5	4.9	0.5	161	48.9	268.8	182	11.33
MT16M06404	80.4	6.4	0.5	184	90.5	71	280	12.71
MT16M07806	80.9	6.1	0.6	157.8	80.1	137	237	11.67
MT16M09602	81.2	5.4	0.4	148.1	70.2	238.7	227	11.63
MT16M10204	77.1	4.1	0.4	148.3	43.9	481.7	167	11.81
Odyssey	80.8	4.1	0.4	139.1	57.2	118.9	181	11.34
Opera	81.9	5.3	0.5	143.9	67.6	183.7	223	10.95
GRAND MEAN	80.425	5.17007	0.44354	167.83197	67.12925	221.15102	216	11.93068
CV	4.5807	6.51861	9.90802	6.99043	10.90545	18.94226	7.56	4.87041
LSD	7.1203	0.65149	0.08495	22.67958	14.1518	80.96448	31.5	1.12306



Table 12: Intrastate Quality

Sidney Dry Intrastate Quality USDA-ARS DATA												
	Kernel	Plumps	Malt	Wort	Wort	Barley	Wort	S/T	DP	Alpha-	Beta-	FAN
Name	Weight	6/64"	Extract	Color	Clarity	Protein	Protein	(%)	(°ASBC)	amylase	glucan	(ppm)
	(mg)	(%)	(%)			(%)	(%)			(20°DU)	(ppm)	(ppm)
Odyssey	42.0	97.5	82.5	1.6	1	10.2	4.80	49.1	103	64.9	63	158
Buzz	53.9	99.0	82.6	1.9	1	11.4	5.84	53.4	117	83.5	283	229
Hockett	51.0	95.4	82.4	1.6	1	11.3	5.66	54.3	160	85.0	153	201
Merit 57	50.8	98.1	81.3	1.4	1	12.1	5.09	43.6	120	69.5	161	215
Metcalfe	48.1	99.3	80.3	2.0	1	12.0	5.92	50.8	106	70.6	272	255
MT090202	45.6	99.1	81.7	n.d.	3	11.1	4.99	45.8	142	66.6	158	180
MT16M00209	46.9	95.2	84.5	2.1	1	10.7	6.28	60.7	126	111.1	82	251
MT16M00305	46.9	98.7	81.6	2.2	1	11.3	5.90	53.6	111	72.1	163	231
MT16M00406	47.4	98.2	83.4	1.9	1	11.1	6.20	58.1	133	107.5	88	264
MT16M00407	47.9	98.2	85.3	2.3	1	10.8	6.04	59.3	99	96.4	128	249
MT16M00408	45.6	97.0	81.4	1.5	1	10.3	4.65	49.4	138	52.1	238	152
MT16M00504	44.7	99.0	84.0	1.8	1	10.8	5.69	56.0	119	108.3	162	227
MT16M00603	42.2	94.6	81.6	1.5	1	10.4	5.28	52.6	174	90.7	202	182
MT16M00610	40.0	97.1	82.5	1.0	1	11.0	4.87	46.7	185	83.0	198	199
MT16M00707	46.7	96.6	81.6	2.0	1	11.6	5.63	49.3	146	91.2	129	291
MT16M00709	45.5	99.0	82.6	n.d.	3	10.7	5.38	53.8	129	80.8	192	190
MT16M00806	46.2	99.3	83.0	1.9	1	10.6	5.88	58.0	130	131.9	104	257
MT16M00807	46.2	97.9	81.6	1.3	1	11.3	5.05	47.1	192	77.8	199	183
MT16M01204	42.4	96.4	81.5	2.0	1	12.6	6.09	51.6	178	118.7	36	275
MT16M01405	52.6	98.9	80.8	n.d.	3	10.7	5.27	52.2	85	59.5	222	191
MT16M01705	44.4	97.1	83.4	1.8	1	10.5	5.57	54.7	111	100.1	184	213
MT16M01801	43.4	99.1	81.1	1.4	1	11.8	4.65	42.8	140	63.4	272	144
MT16M01803	50.1	98.1	81.1	1.7	1	12.1	5.53	46.8	148	67.3	158	196
MT16M01806	47.5	99.0	81.5	2.2	1	11.5	5.67	50.1	145	79.2	139	264
MT16M01819	49.1	97.3	82.4	1.7	1	11.1	5.77	56.1	145	100.6	94	216
MT16M01901	48.0	97.7	81.8	2.1	1	10.5	5.60	53.8	123	86.2	144	224
MT16M02003	45.4	99.0	81.2	1.9	1	10.3	4.86	48.6	102	67.9	234	167
MT16M02008	40.5	95.5	83.5	2.0	1	9.9	5.78	63.4	140	122.7	45	248
MT16M02101	48.9	97.7	79.3	1.9	1	11.1	5.50	51.2	172	75.0	92	198
MT16M02106	45.8	97.3	82.4	1.8	1	10.9	5.97	56.1	180	114.7	65	272
MT16M02107	49.7	97.3	81.1	1.7	1	11.1	5.45	50.1	159	95.6	175	214
MT16M02201	42.8	95.6	81.1	1.5	1	11.8	4.88	44.0	155	64.9	196	153
MT16M05403	46.0	96.0	80.7	1.9	1	11.6	6.07	52.6	81	100.2	76	266
MT16M05610	45.8	96.4	81.2	2.1	1	11.9	5.89	52.6	174	102.6	65	279
MT16M05902	49.0	96.9	81.9	n.d.	3	10.4	4.79	49.7	119	65.2	231	133
MT16M06110	50.7	99.0	80.8	1.6	1	12.4	5.27	44.7	133	65.6	231	187
MT16M06404	47.4	98.5	82.3	1.8	1	11.0	5.76	55.6	122	99.2	74	223
MT16M07806	45.8	95.0	83.4	1.5	1	10.3	5.17	53.3	150	90.6	239	203
MT16M09602	46.5	98.0	82.2	1.7	2	10.5	4.92	48.2	155	68.7	221	156
2IM14-8212	44.3	98.2	82.2	2.4	1	10.2	5.76	62.9	136	121.1	99	254
						All malt quality				Poor quality		
						Adjunct quality						



Table 13: Intrastate Quality

Variety or Selection	Creston Intrastate Malt Quality USDA-ARS Data									
	Kernel	Plumps	Malt	Barley	Wort	S/T	DP	Alpha-	Beta-	FAN
	Weight (mg)	6/64" (%)	Extract (%)	Protein (%)	Protein (%)	(%)	(°ASBC)	amylase (20°DU)	glucan (ppm)	(ppm)
Bow	49.0	99.4	81.9	11.4	6.09	54.9	113	105.1	80	316
Buzz	49.8	98.5	82.3	10.9	5.59	54.7	105	109.1	191	275
Ellinor	49.1	99.6	82.2	11.0	4.99	47.1	84	73.3	213	169
Fraser	49.4	99.1	82.4	11.5	6.08	55.0	112	105.9	110	217
Genie	45.9	97.4	80.6	11.6	5.50	50.9	110	98.7	254	202
Hockett	51.3	95.5	81.8	12.1	5.69	48.7	110	80.8	369	200
Leandra	53.6	99.2	81.4	11.5	5.45	48.8	129	99.1	92	191
Merit 57	45.3	98.9	83.2	10.2	5.41	54.2	97	105.6	168	262
Metcalfe	47.0	96.5	82.2	12.1	6.15	54.8	148	109.7	116	239
Odyssey	48.8	98.7	83.1	10.2	4.54	46.3	79	56.9	151	179
Opera	53.2	99.7	83.3	10.3	4.69	47.7	77	67.0	321	205
IK14-8413	49.3	97.8	81.8	12.1	5.66	48.2	138	102.2	113	297
2IM14-8212	49.8	99.3	80.8	11.5	5.77	52.7	111	106.9	193	281
MT090202	48.0	99.1	80.7	11.0	4.85	44.9	122	68.8	419	191
MT16M00209	57.1	99.3	81.9	10.6	5.16	49.4	82	65.9	366	217
MT16M00305	51.7	98.4	80.9	11.6	5.60	50.0	69	81.5	174	258
MT16M00406	55.4	98.9	80.9	11.1	5.15	48.0	128	81.8	443	212
MT16M00407	53.0	99.3	81.8	12.0	5.06	43.3	97	57.3	519	203
MT16M00408	51.1	99.0	81.5	11.7	5.95	51.7	101	69.4	333	293
MT16M00504	57.9	99.7	81.9	12.4	5.54	46.5	111	75.0	532	235
MT16M00603	52.4	98.6	81.2	12.8	5.40	43.4	114	63.5	339	245
MT16M00610	52.1	98.9	81.9	12.0	5.55	47.1	138	66.1	352	198
MT16M00707	49.6	99.4	82.2	11.2	5.08	48.1	121	69.0	379	205
MT16M00709	52.3	99.0	81.9	10.4	4.73	46.4	92	52.2	369	177
MT16M00806	55.6	98.7	80.9	12.7	5.37	42.5	120	73.5	501	152
MT16M00807	52.2	98.7	82.5	11.1	5.48	49.6	91	66.9	326	225
MT16M01204	54.8	99.5	79.4	11.9	5.20	45.4	187	70.1	310	207
MT16M01405	49.6	99.4	81.3	11.3	4.64	43.4	97	62.4	365	181
MT16M01705	49.3	97.2	81.9	11.7	5.59	49.5	144	84.1	297	196
MT16M01801	50.4	98.9	82.2	10.7	5.01	50.3	125	87.5	410	234
MT16M01803	49.3	98.9	80.9	11.6	5.01	44.0	137	63.0	416	152
MT16M01806	51.1	99.2	82.4	10.3	4.64	46.7	100	60.7	375	194
MT16M01819	47.5	98.8	81.4	12.0	4.75	40.6	116	53.4	492	137
MT16M01901	53.6	99.4	81.1	11.5	5.34	48.8	131	79.1	283	240
MT16M01902	49.8	97.5	80.9	11.5	4.90	43.3	123	67.6	428	162
MT16M02003	45.9	97.4	82.0	12.0	5.04	44.2	176	71.2	530	157
MT16M02008	49.8	99.3	82.3	10.9	5.11	47.7	116	66.8	279	219
MT16M02101	53.2	96.0	84.0	10.9	5.88	56.2	90	83.4	223	219
MT16M02106	48.3	97.9	82.1	11.1	4.95	47.2	97	82.4	368	191
MT16M02107	51.8	96.3	81.2	12.3	5.79	47.3	189	90.2	352	224
MT16M02201	50.5	98.0	*84.9	11.5	5.83	55.7	83	85.2	349	258
MT16M05403	46.6	96.2	80.8	12.0	5.38	47.2	130	73.1	446	202
MT16M05610	51.3	99.0	82.1	11.2	6.04	57.4	138	98.7	303	241
MT16M05902	51.0	98.7	81.4	11.6	5.33	47.5	142	68.2	311	176
MT16M06110	50.3	99.0	81.9	10.6	5.10	48.9	126	65.1	332	156
MT16M06404	50.4	99.4	81.2	12.9	6.57	52.8	132	108.9	275	256
MT16M07806	49.9	98.7	81.7	11.7	5.70	51.9	104	86.6	291	163
MT16M09602	52.7	99.0	83.3	11.0	5.96	56.2	94	84.9	219	242
MT16M10204	46.0	95.6	80.1	12.3	4.53	37.2	79	48.3	607	157

Table 14: Early Yield Trial Agronomic

name	2019EYT NARC							EYT19Bzdry							
	yield	protein	height	plump	test_weigh	heading	maturity	yield	protein	height	plump	lodging	test_weigh	heading	maturity
Hockett	78.3	12.2	71.6	94.7	54	174	204.3	128.8	12.2	86.8	93.7	73	54.8	187	226
Merit 57	84.7	12.5	77.4	90.1	49.7	175.3	207.3	145.2	12	87.3	93.3	0	54.4	190	231.3
Metcalfe	82.9	12.9	74.4	93	53	175.3	204.7	135.7	12.6	92.7	94.8	0	54.7	187.3	226
Odyssey	92.7	11.9	65.3	93	51.1	179.7	206	159.5	10.7	74.3	96.5	0	53.1	192.7	231.3
MT124112	89.8	10.9	66.4	91.9	52.6	173	205.7	137.5	10.8	85.3	96.6	3	54.5	187.3	230.3
MT16M06402	85.9	12.4	72.9	92.6	51.9	176.3	207.3	153.3	12.1	88	95.7	0	55.2	188.7	230.3
MT16M08502	82.7	12.4	74.9	94.6	53.6	176.7	205	155.7	12.3	87.5	97.7	0	56.3	188	225.3
MT16M01303	88	12	74.9	95.3	52.9	172.7	205.7	150.3	12.4	90.3	97.8	0	55.3	187	228.7
MT16M01820	89.7	11.1	71.6	93.8	51.9	172.3	205.3	156.4	10.6	83.3	96	0	54.6	187	228
MT16M06007	89.9	12.5	63.5	85.3	53.6	168	204	134.2	12	83.5	93.6	0	55.3	181.3	224.3
MT16M07910	93.2	12.2	69.2	85.8	52.7	175.7	205.3	154.1	11.6	86.3	84.4	0	54.5	190	228.7
MT17M00210	85.7	12.3	76.2	97.4	52.9	168.7	206	124.1	12	92.3	98.2	30	55.2	181.3	229
MT17M00301	90.8	11.7	75.5	95.2	51.4	175.7	206	118.7	12.4	86.2	97.5	78	53.7	190	230
MT17M00302	88.4	11.2	82.3	91.4	51.8	177	207.3	159.6	10.4	92.3	97.1	0	55.7	190.7	233.3
MT17M00502	85.2	12.1	65.6	92.6	50.6	172	207.3	163	12.3	90	97.7	0	54.1	186.3	226.7
MT17M00504	102.4	11.6	69	90.6	52	172	207	154.9	11.4	87.8	97.5	0	54.6	186	229
MT17M00710	82.6	11.7	73.4	96.4	51.9	171.3	205.7	153.9	11.3	91.7	98.5	0	55.4	187	232.7
MT17M01302	90.4	11.6	67.5	91.4	51.5	168.7	205	144.3	12.2	87	97.1	0	54.3	182.3	227
MT17M01306	90.9	12	75.1	92.4	52.3	172.3	207.3	151	11.6	91.2	97.3	0	55.2	186.3	230
MT17M01710	75.1	12.3	65.8	92.3	51.2	171.7	205	142.2	12	85.3	95.4	0	54.7	182.3	226
MT17M01711	111	11	71.1	91.9	51.2	173	204	147.3	11.1	83.3	94.5	0	53.5	187.3	227
MT17M01801	73.1	11.6	76.1	94.1	52.6	174.7	205.7	147.8	11.4	88.7	96.9	0	55.8	188.3	230.3
MT17M01808	97.9	12	74.5	95.2	52.8	172.3	207.7	145.5	11.8	90.8	96.5	0	55	186	228
MT17M01906	91.9	11.9	67.6	95.8	51.5	173.7	206.3	149.4	11.6	88	95.2	0	53.7	186	230
MT17M01908	87.2	11.3	73.9	97.4	51.7	173.7	206	148.4	11.1	89	97.8	0	54.4	186.7	230
MT17M01912	79.8	10.9	81.1	97.1	52.6	174.7	207	149.5	10.5	93.3	97.7	0	55.4	188.3	231
MT17M02003	96.7	12.1	74.8	95.5	51.6	172.7	204.7	154.4	11.7	90.3	97.9	0	54.7	186	230.7
MT17M02009	96.2	11.5	77.3	96.8	51.8	173.3	206.3	157.9	11.4	92.7	97.2	0	53.8	188	228
MT17M02106	95	12.3	68.5	93	51.8	170.3	204.3	142	11.9	87.3	95.6	0	54.3	184.7	225.7
MT17M02507	103.1	10.7	78	97.2	52.8	174	207	157.2	10.3	91.3	96.9	0	55.2	188.3	230.7
MT17M02510	94.6	11.6	64.4	94.4	52.9	171	205.7	139.7	11.5	83	96.2	0	54.9	184.3	226.7
MT17M04801	98	12	78.8	91.4	52.1	175	207.7	161.1	11.5	88.8	96.6	0	55.6	187	229.7
MT17M04808	78.3	10.5	84.8	93.1	52.1	176.3	206.3	154	11	90	94.7	5	54.6	189.7	230.7
MT17M04904	78.3	12.6	82.9	87.9	51.8	179	208.3	153.2	11.4	95	96.5	0	55.6	190.3	233
MT17M05106	77.8	11.6	80.4	85.8	53.1	174.3	206	146	11.7	93.3	91.2	5	55.2	188.7	230
MT17M05201	82	12.8	71.5	92.6	51.1	173	206	133.6	12.9	87	95.3	12	53.4	187	224.7
MT17M05312	93.8	11.4	78.1	91.8	51.8	175	205.7	136.4	11.9	84.8	84	52	52.7	190	228.7
MT17M05416	87.7	10.4	81.3	93.1	51.7	175.3	206.7	151.6	11.4	86.2	95.6	0	55.4	188	229.7
MT17M05502	76.7	12.2	88.6	94.8	52	178	207	160.1	11.4	95	97.8	0	55.5	187.7	228
MT17M05508	84.3	12.1	80.8	94.6	52.4	175.7	204.7	154.9	11.2	91.5	97.3	0	54.9	188	227
MT17M05609	76.6	11.5	83.8	92	52	175.7	207	149.4	10.7	95	96.2	0	55.3	187	231
MT17M05808	73.5	12.3	77.8	94.5	52.5	174.3	204	126.9	12.3	90.3	93	27	54.1	187.7	224.7
MT17M05812	87.5	12.6	79.7	95.7	53.3	173.7	205.7	144.2	12.4	94.2	96.2	18	55.2	187.3	226
MT17M06010	80	12.2	66.2	94.3	53.9	170.7	207.3	136.7	11.6	85.2	97	0	55.8	182	229
MT17M07605	91.2	12	70.3	90.4	51.1	171.7	204	124.4	12.4	80.7	91.1	58	54	186.7	224.3
MT17M07704	80.5	12.3	69.8	94.8	52.8	174	204	130.6	12.6	86	93.8	8	54.5	186.7	224.7
MT17M07901	75.5	12.1	68.7	87.5	51.2	177.3	208	150.3	10.3	85.3	93.2	0	54.1	189.3	226.7
MT17M07902	83.4	11.3	73.7	85.1	52.8	174	205.7	155.7	10.9	88	87.7	0	54.4	187	227.7
MT17M07904	88.2	11.7	77	85.8	51.6	175.7	206.3	135.8	11.2	88.2	87.7	3	53.4	188	229
MT17M08001	80.1	12.4	72.1	93	52.2	172.3	204.7	140.7	11.9	86.2	96.7	0	54.7	182	227.3
MT17M08016	79.9	11.7	74.5	95.3	52.3	174.3	207.7	137.8	11.3	88	97	0	54.8	185	231
MT17M08208	101.7	11.5	66.1	94.7	52.9	176.7	204.3	140.5	13.2	83.2	90.4	25	53.8	189.7	226
MT17M08213	89.5	11.5	73.4	93.7	52.3	176.7	207.3	150.9	11.5	86.3	96.6	0	54.9	192	232.7
MT17M08403	87.8	12.3	69.9	85.4	51.9	176.3	206	161.5	12	87.3	89.3	7	55.2	191	228.3
MT17M08404	84.2	13.2	76.5	83.6	50.6	177.7	206	151.5	12.4	88.8	93.1	0	54.6	192.3	231.3
MT17M08501	89.9	12.2	71	93.3	53.8	172	205	143.1	12.2	86.7	94.1	7	55.7	187	223.7
MT17M08509	88.2	12.4	76.7	90.7	52.5	177	205.3	148.9	12	86.2	96.6	0	55.7	189	226.7
MT17M08702	93	11.2	71.5	96.5	53.7	172	205.3	142.8	10.8	82.7	96.5	0	55.8	187	232
MT17M08804	95.5	11.6	65.2	88.8	53.7	169.7	205	144.3	11.4	82.3	96.5	0	56.1	182	225.3
MT17M08806	86.6	11.7	63.5	89.8	52.8	171.3	207.3	138.9	10.9	85.3	95.6	0	55.3	186	228.3
MT17M08808	92.6	11.1	71.7	93.6	52.6	171.7	205.7	156.8	11	84.7	95.6	18	55.2	187.3	229.3
MT17M09010	85.9	11.5	76.5	87	50.9	177.3	207.7	146.7	11.3	89.8	97.2	0	55	191.7	231
MT17M09011	82.6	11.8	81.2	87.9	52.1	177.7	208.3	138.9	11.7	89	95.2	25	54.4	192	231
MT17M09602	77.7	10.7	78.8	94.7	52.4	174.3	207.3	153.6	10.2	91	96.5	0	55.6	187.3	233
<b>GRAND MEAN</b>	<b>87.26</b>	<b>11.82</b>	<b>73.79</b>	<b>92.37</b>	<b>52.25</b>	<b>174.02</b>	<b>206.02</b>	<b>146.30</b>	<b>11.59</b>	<b>87.96</b>	<b>95.17</b>	<b>7.10</b>	<b>54.80</b>	<b>187.38</b>	<b>228.65</b>
CV	7.01	3.76	5.04	2.67	0.85	0.91	0.59	4.06	1.83	2.46	1.10	107.14	0.63	0.37	0.50
LSD	11.77	0.86	7.15	4.75	0.85	3.03	2.32	11.42	0.41	4.16	2.02	14.64	0.67	1.34	2.19
Min. Plot	66.60	9.80	60.00	80.30	49.20	168.00	203.00	109.10	10.00	74.00	79.80	0.00	52.40	181.00	222.00
Max. Mean	111.00	13.20	88.57	97.43	54.00	179.67	208.33	162.97	13.23	95.00	98.50	78.33	56.27	192.67	233.33



Table 15: Early Yield Trial Agronomic

name	EYT19EARCDry							EYT19CARCDRY						
	yield	protein	height	plump	lodging	test_weig	heading	yield	protein	height	plump	test_weig	heading	
Hockett	133.7	12.2	75	93.4	47	54.7	172	55.1	9.8	27	90.5	55.6	188	
Merit 57	139.8	12.2	75.7	92.6	13	52.5	175.7	59.8	9.8	24.7	75.3	52.7	188.7	
Metcalfe	132.4	13	75.3	94.3	37	53.4	171.3	53.4	10.2	24	85.4	54.5	186.7	
Odyssey	132.4	11.5	64.3	96.5	53	52.1	175.3	69.8	9.1	22	80.3	53.9	190	
MT124112	126.3	11.9	70	95.9	0	53.2	171.7	51	9.6	23.3	93	54.6	187	
MT16M06402	145.1	12.5	73.7	94.9	0	54.3	171.7	71.5	9.6	26.3	86	55.5	188	
MT16M08502	119.4	12.4	68.7	94.8	0	54.8	175.3	60.4	9.9	24.3	88.2	55.5	189	
MT16M01303	126.9	12.8	77.3	97.4	0	53.4	171.7	71.6	10.8	28.3	94.7	56.1	186.3	
MT16M01820	122.5	11.6	67.3	93.9	0	52.2	171	62.6	8.5	23.3	84.1	53.8	184.3	
MT16M06007	131.7	13.4	69.3	95.6	0	53.9	168.3	68.8	10.4	25.3	87.1	55	185	
MT16M07910	128.5	11.8	69.3	88.3	77	54	172	71	9.5	25	62.1	52.3	188	
MT17M00210	122.1	13.6	76.3	97.8	0	53	168.3	62.8	10.5	27	95.5	57	186	
MT17M00301	129	12.3	74	97.5	10	52	174	70.6	10.3	28	89.7	55.1	188.3	
MT17M00302	151.1	11.3	75.7	95.1	0	54.1	175.3	73.2	9.8	31	90.4	54.5	189.3	
MT17M00502	133.9	12.5	74	97.7	0	51.7	169.3	76.6	10.6	31	93.7	54.9	185.3	
MT17M00504	138.4	12.6	73.7	95.7	0	52.5	169	71.9	9.7	27	90.8	55.7	185.7	
MT17M00710	134	11.8	75.3	98.8	0	53.5	169.7	70	9.9	27.7	94	55.7	185.7	
MT17M01302	137.2	12.8	69	96.8	0	52.5	168	64.1	10.5	26.7	95.9	54.6	185.3	
MT17M01306	144.6	12.9	74	97.5	0	52.6	170.3	64.6	10	28.7	96	55.5	185.7	
MT17M01710	124.4	11.9	69	94.5	47	54	168.7	62.8	10.1	23	87.2	53.7	186	
MT17M01711	115.6	12.2	72.3	89.6	97	50.8	170.7	63.5	9.6	24.3	74.2	53.4	187.3	
MT17M01801	128.4	11.5	78.7	95.9	0	54.3	171	68.9	10	27	91.2	55.5	187	
MT17M01808	126.3	12.8	64	93.8	27	52.9	169.3	72	10.4	26.7	85.4	55.1	185	
MT17M01906	132.7	12.5	71.3	94.9	0	51.7	171	65.6	9.6	25.3	83.5	54.1	185	
MT17M01908	122.9	11.6	74.7	97.9	0	52.7	169.3	60	9.6	27	93.6	54.6	186.3	
MT17M01912	136.3	10.9	82.3	98.4	0	53.7	171.7	60.8	8.9	25.3	95.3	54.9	186.7	
MT17M02003	120.5	12.5	74.7	97.9	0	51.9	170	69.1	9.8	27.3	89.6	54.6	187	
MT17M02009	128.2	11.6	77	96.8	0	51.8	171.7	68.7	10.1	28.7	87.7	54.7	185.7	
MT17M02106	122.1	12.6	68.3	93.6	7	52.3	169	63.8	10.2	24.3	87	55.3	185	
MT17M02507	138.5	10.8	75.7	96.4	0	53.7	173	73.4	8.8	26	92.9	54.9	185.7	
MT17M02510	131.1	11.6	64.3	96.9	0	54	168.7	68.7	9.7	23.3	94.9	54.3	185	
MT17M04801	145.7	11.8	73.3	95.2	28	53.9	171.7	70.5	10	28	86.9	55.7	186.3	
MT17M04808	125.9	11.2	77.7	93.2	17	53.7	174	67.3	9.5	27.3	87.9	55.2	187.3	
MT17M04904	136.7	12	71.3	95	0	53.5	176	71.7	10.3	28.3	80.8	55.4	187.3	
MT17M05106	141.5	11.9	79.7	89.5	13	54.2	172	56	9.3	25.7	73.7	55	186	
MT17M05201	111.8	13.3	69.3	95.1	7	51.4	170	50.9	10.1	23.7	90.7	55.5	187.3	
MT17M05312	150.8	11.7	79	94.1	0	53.1	175	72.6	10.2	26.7	67.3	53.5	189.7	
MT17M05416	117.7	11.7	70.7	92.4	3	52.5	174.3	69.2	10.5	27	87.6	54.9	188	
MT17M05502	140.6	11.8	79.3	96.2	13	54	174.3	64.4	10.1	29.3	90.1	54.6	187.7	
MT17M05508	141.4	11.3	82	95.7	0	54	172	64.8	9.4	28	86.9	54.6	186.3	
MT17M05609	124.4	11.8	81	95.1	0	52.8	172.7	55.7	9.6	28	88.2	54.8	187.3	
MT17M05808	119.1	12	72	93.7	80	53.1	171	60.3	10.1	26.7	86.4	55.5	188	
MT17M05812	128	13	80	95.1	53	53.7	171	62.5	10.4	27.3	82.5	55.3	187.3	
MT17M06010	138.3	12.6	65	97.8	0	54.1	168.3	55	9.9	23.3	95.6	55.9	185	
MT17M07605	131	11.9	65.3	91	100	53.1	169	51.7	9	22.7	88.8	55.4	186.7	
MT17M07704	143.5	12.3	74.3	94.3	57	54.2	169.7	63.7	10.5	28.3	86.3	54.9	188.7	
MT17M07901	136.2	11	72.7	91.7	98	43.2	173.3	67.4	10	26	78.3	52.7	189.3	
MT17M07902	131.6	12	76	91.2	0	53.7	171.7	64.6	8.9	24	71	53.3	186.3	
MT17M07904	142.2	11.4	74.3	89.5	50	53.4	172	61.8	9.2	26.3	70	51.4	189	
MT17M08001	128.5	12.8	68.7	96.3	30	54.1	168.7	61.1	9.7	25.7	94.5	55	186.7	
MT17M08016	135.4	12.6	75	96.6	0	53.6	169	57.8	9.7	27.7	90	54.5	186.7	
MT17M08208	134.1	13.9	62.7	92.1	0	52.9	174	77.3	10.5	26.7	79.5	54	188	
MT17M08213	139.8	12.3	69.3	97.1	0	54.2	175.3	66.1	10.2	27.7	82.3	54	190	
MT17M08403	149.7	12.6	74.7	91.7	20	53.3	175.3	68.6	9.9	24.7	74.7	54.1	189	
MT17M08404	88.4	12.3	73.3	92.5	17	53.9	175.7	65.2	10.7	26.3	67.1	52.4	188.7	
MT17M08501	127.8	11.8	64	93.5	83	54.7	170.7	64	9.1	23	85.8	56.1	186.3	
MT17M08509	125.1	12.8	72.3	95.4	23	54.2	174	65.6	10	24.7	68.3	54.5	188.7	
MT17M08702	132.8	11	70	92.3	3	54	171	59.3	9.3	24	86.4	55.1	185.7	
MT17M08804	125.2	12.5	66	96.3	0	53.8	168	57.8	9.8	23	92.4	56.4	185.7	
MT17M08806	135.3	11.9	68	98.3	0	54.1	168.7	48.5	9.8	22.3	91.6	55.3	186	
MT17M08808	146.7	11.1	71	96.7	0	53.7	169	69.6	9.6	24.3	85.3	54.7	187	
MT17M09010	137.1	10.9	76.3	95.6	0	53.6	175	56.8	9.5	27	87.7	53.8	189.3	
MT17M09011	136.9	11.8	77	95.5	0	53.9	174.3	62.8	9.9	30	80.9	54.7	188.3	
MT17M09602	135	10.5	72.7	94.1	7	53	171.7	68.3	9.6	28.7	91.4	55.7	187.7	
<b>GRAND MEAN</b>	<b>131.89</b>	<b>12.09</b>	<b>72.72</b>	<b>94.85</b>	<b>17.45</b>	<b>53.17</b>	<b>171.60</b>	<b>64.46</b>	<b>9.84</b>	<b>26.11</b>	<b>85.82</b>	<b>54.72</b>	<b>187.05</b>	
CV	11.59	4.71	6.57	1.83	106.78	3.68	0.63	13.47	5.78	5.89	5.22	1.28	0.57	
LSD	29.41	1.09	9.20	3.34	35.85	3.76	2.08	16.70	1.09	2.96	8.62	1.35	2.06	
Min. Plot	0.00	9.30	56.00	85.00	0.00	26.00	168.00	40.70	8.00	21.00	52.40	50.10	182.00	
Max. Mean	151.07	13.90	82.33	98.77	100.00	54.83	176.00	77.33	10.77	31.00	96.00	57.03	190.00	



Table 16: Early Yield Trial Quality

Variety or Selection	Sidney EYT Malt Quality USDA-ARS Data									
	Kernel	on	Malt	Barley	Wort	S/T	DP	Alpha-	Beta-	FAN
	Weight (mg)	6/64" (%)	Extract (%)	Protein (%)	Protein (%)	(%)	(°ASBC)	amylase (20°DU)	glucan (ppm)	(ppm)
Hockett	46.9	96.5	81.7	11.6	5.59	46.4	167	95.6	171	198
Merit 57	41.5	95.1	82.7	11.8	5.84	50.5	175	117.9	68	201
Metcalfe	40.0	94.1	81.2	12.5	6.32	49.0	190	116.4	42	234
Odyssey	43.6	98.5	82.5	10.6	4.75	46.2	140	69.2	55	156
MT124112	47.7	97.9	83.6	10.5	5.75	58.7	154	122.9	59	242
MT16M06402	43.8	97.1	81.0	12.1	5.01	41.9	154	76.4	234	158
MT16M08502	45.6	97.6	80.2	12.1	4.62	39.0	153	62.4	265	127
MT16M01303	47.0	99.1	80.6	12.5	4.87	39.9	123	68.9	204	144
MT16M01820	43.4	94.8	83.2	11.5	5.68	50.1	123	107.4	182	219
MT16M06007	46.5	97.1	82.2	12.6	6.39	50.8	139	104.9	348	217
MT16M07910	40.0	94.2	80.8	11.0	4.83	46.2	112	82.7	127	170
MT17M00210	48.3	99.0	82.0	13.0	6.53	52.2	108	93.1	394	252
MT17M00301	53.6	98.9	82.5	11.5	6.03	57.4	113	83.9	147	266
MT17M00302	43.4	97.0	80.8	11.5	5.24	44.9	237	76.4	145	179
MT17M00502	51.6	98.8	80.6	12.0	5.82	49.8	154	72.3	184	184
MT17M00504	48.9	96.8	80.8	12.4	5.69	48.6	149	87.5	324	210
MT17M00710	51.0	99.4	81.4	11.7	5.30	46.7	145	65.4	236	155
MT17M01302	47.3	97.4	80.8	12.3	5.35	43.8	167	74.2	249	157
MT17M01306	50.3	97.0	81.1	11.8	5.47	49.6	122	68.2	385	173
MT17M01710	47.3	97.2	81.1	12.1	5.07	45.1	184	66.5	340	173
MT17M01711	42.2	93.5	81.7	12.2	5.10	44.3	169	74.0	61	196
MT17M01801	44.4	97.8	81.4	11.4	4.82	44.2	199	72.2	341	158
MT17M01808	42.3	96.4	82.1	11.8	5.02	42.7	175	72.7	387	152
MT17M01906	44.5	97.1	81.8	11.5	4.67	43.6	190	66.3	269	137
MT17M01908	49.5	97.8	81.4	11.7	5.60	49.7	202	80.4	44	191
MT17M01912	47.5	98.5	81.7	10.7	5.13	49.9	193	81.8	86	173
MT17M02003	47.8	98.8	81.4	12.0	5.11	41.9	212	64.5	245	175
MT17M02009	46.5	97.9	81.2	11.1	4.89	45.5	186	72.4	110	171
MT17M02106	43.5	94.2	81.4	12.3	5.21	44.7	151	61.1	478	151
MT17M02507	43.6	98.1	83.3	10.9	5.15	48.1	77	81.3	262	154
MT17M02510	50.2	97.8	81.5	11.9	5.17	46.0	93	77.6	213	173
MT17M04801	46.5	97.8	80.7	12.2	5.11	45.3	173	70.2	241	158
MT17M04808	45.0	96.3	81.6	11.1	4.87	47.7	169	69.3	267	147
MT17M04904	43.5	96.9	82.6	11.4	5.55	48.8	145	87.9	129	223
MT17M05106	40.5	93.0	81.0	11.2	4.59	43.3	142	56.5	104	132
MT17M05201	43.4	96.2	81.9	11.8	5.74	49.0	156	100.7	232	213
MT17M05312	42.3	96.1	81.7	11.6	4.95	42.5	185	79.8	145	168
MT17M05416	41.6	95.4	82.4	12.1	5.59	48.0	159	104.2	27	230
MT17M05502	45.7	97.2	80.4	12.2	5.61	47.8	168	91.4	77	195
MT17M05508	44.6	97.9	82.3	11.4	6.06	54.8	184	126.0	40	251
MT17M05609	41.9	97.4	80.7	11.8	4.89	42.0	196	67.9	116	142
MT17M05808	45.2	96.6	82.4	12.2	6.40	51.0	204	118.2	59	255
MT17M05812	45.7	97.1	82.1	12.4	6.01	48.6	218	117.3	108	232
MT17M06010	50.1	97.5	82.7	12.2	6.40	52.9	170	95.6	275	258
MT17M07605	44.4	98.1	84.0	10.9	5.60	56.5	168	90.0	192	184
MT17M07704	43.7	95.6	82.6	12.1	6.33	52.6	167	96.8	184	236
MT17M07901	38.9	*91.2	81.7	11.9	5.29	46.8	71	81.5	168	223
MT17M07902	40.5	94.9	80.4	10.8	4.22	42.1	52	46.2	353	116
MT17M07904	40.2	95.9	81.0	10.9	4.85	44.8	87	64.3	84	155
MT17M08001	46.8	*70.1	80.4	12.2	4.89	38.3	215	77.8	300	159
MT17M08016	46.3	97.9	82.2	13.2	6.05	47.3	147	112.6	72	248
MT17M08208	44.4	93.5	78.7	12.9	6.17	49.2	137	96.7	133	230
MT17M08213	52.1	98.2	80.4	11.6	4.97	42.3	149	70.8	208	164
MT17M08403	42.0	94.6	79.4	11.9	4.61	39.3	178	69.7	223	130
MT17M08404	40.8	95.8	81.8	12.0	5.56	48.9	149	98.7	138	211
MT17M08501	42.0	95.9	79.5	11.6	4.42	37.4	154	62.8	293	113
MT17M08509	45.7	97.6	79.1	12.3	4.49	34.8	169	59.2	329	117
MT17M08702	47.0	96.2	83.2	11.1	6.02	55.2	144	91.0	189	249
MT17M08804	46.7	96.8	81.1	11.8	5.00	45.8	123	64.0	383	161
MT17M08806	47.7	98.5	81.2	11.6	5.37	50.7	100	72.0	251	175
MT17M08808	48.4	97.4	80.8	12.3	5.02	42.5	133	68.1	305	175
MT17M09010	43.6	96.9	82.7	10.8	5.61	54.0	151	105.0	88	190
MT17M09011	45.0	97.5	79.5	12.2	5.08	41.5	155	65.1	317	151
MT17M09602	45.1	97.6	83.1	10.1	5.12	53.7	138	81.6	213	175

2019 Barley, Malt & Brewing Quality Lab work summary:

**Research:**

Completed analysis for the MSU breeding program:

2018 AMBA – 16 Micro samples

2018 128.148 – 192 Micro samples

2018 Offstation – 148 Micro samples

Glycosidic Nitrile – 96 Micro samples malted (testing @ Hartwick)

2018 Sulphur – 200 Micro samples

Post Farm and MBA Wort tastings – 74 Micro samples

Pico Method Publication – 96 Micro samples, 96 Pico samples

2019 Fertility – 85 Micro samples

2019 Intrastate – 160 Micro samples

2019 PYT – 192 Micro samples

Totals:

1311 Micro samples

96 Pico samples

Collaborative Research:

B-Glucan – USDA collaboration – published in the Journal of American Society of Brewing Chemists 2019

*Effect of Steeping Regime on Barley Malt Quality and Its Impacts on Breeding Program Selection*

Glycosidic Nitrile – Hartwick College: Research pending publication

Publications:

Optimization of Pico Malting for improved barley breeding

Data generation complete, writing in process.

**Outreach:**

Tours given: 22

This includes a handful of maltsters during tours of the 2019 Craft Malt Conference held here on campus, student programs, news services (YPR & NBC), Bozeman Homebrew club and The Pink Boots



Society, stakeholders and potential revenue streams for the state such as Heineken and a group from China.

We are expanding our positive footprint on the industry by offering more educational opportunities such as now co-teaching the Advanced Class in Craft Malt Production – a staple program for North American Craft Maltsters, hosting the Brewer’s Association’s Basics of Beer Quality workshop, developing a two day Malt for Brewers course (coming on board summer 2020), and starting to offer classes which have the largest reach into the community – required alcohol service training “Your Community Matters”.

**Service:**

Active clients: 28

Clientele include Maltsters, brewers, and peer research programs. Clients are both local, regional, and international including Canada and 18 states. In 2019 we have expanded our analysis offerings and have brought on beverage quality testing.

Third Party samples tested:

Malt: 361 samples

Barley: 31 samples

Beverage: 11