

## MSU CEREAL RYE VARIETY TRIALS – 2020-2021

With the support of the Michigan Craft Beverage Council, trials to compare cereal rye varieties were established in the fall of 2019 at three locations in Michigan. Data were collected to evaluate **suitability for use in the distilling industry**. Plots included 15 varieties with four replications (2020) and 21 varieties with six replications (2021) in a randomized complete block design. Two locations (Hickory Corners and Chatham) included four additional replicates in 2020 with enhanced management including a plant growth regulator and fungicide application.

### Hickory Corners, MI - 2020

Variety	Yield (bu/A)	Density (lb/bu)	Heading Date	Height (m)	Lodging (0-5) <sup>§</sup>	Spring Vigor <sup>#</sup> (0-10)
<b>Normal Management</b>						
AC Hazlet	77.1	53.7	5/26	1.61	3.38	10
Aroostook	54.3	53.1	5/22	1.78	2.75	10
Danko	77.0	54.4	5/25	1.48	1.13	10
Elbon	51.2	55.1	5/22	1.76	2.33	10
FL401	37.0	53.7	5/22	1.82	1.38	9
Guardian	65.6	53.3	5/26	1.71	3.50	10
KWS Bono*	100.1	53.9	5/26	1.35	2.00	10
KWS Brasetto*	99.0	53.6	5/26	1.35	1.38	10
KWS Serafino*	99.7	53.9	5/26	1.45	2.00	10
Maton	48.2	54.8	5/21	1.76	2.63	9.75
Merced	38.8	53.5	5/21	1.52	3.88	8.75
ND Dylan	67.8	52.8	5/27	1.75	3.00	9.75
VNS	71.8	54.0	5/26	1.61	2.00	9.5
Wheeler	34.5	52.1	5/27	2.02	0.13	10
Wrens Abruzzi	41.2	55.0	5/22	1.73	2.75	10
<b>Normal Mean</b>	<b>64.4</b>	<b>53.8</b>	<b>5/24</b>	<b>1.64</b>	<b>2.28</b>	<b>9.76</b>
<b>Enhanced Management</b>						
AC Hazlet	70.8	54.3	5/26	1.66	3.00	10
Aroostook	54.5	54.3	5/22	1.77	2.63	10
Danko	78.4	55.1	5/26	1.46	0.75	10
Elbon	50.8	55.2	5/22	1.74	2.40	10
FL401	35.4	54.3	5/21	1.76	2.50	9
Guardian	71.3	54.6	5/25	1.67	2.75	10
KWS Bono*	103.8	54.5	5/26	1.30	1.25	10
KWS Brasetto*	108.4	54.4	5/26	1.38	0.38	10
KWS Serafino*	112.4	54.5	5/26	1.30	0.63	10
Maton	47.0	55.6	5/21	1.75	3.00	9.75
Merced	44.6	54.9	5/21	1.50	3.50	8.75
ND Dylan	60.8	53.6	5/26	1.71	2.88	9.75
VNS	69.3	54.7	5/26	1.60	1.50	9.5
Wheeler	37.3	52.8	5/26	1.97	0.13	10
Wrens Abruzzi	56.4	55.5	5/23	1.71	2.75	10
<b>Enhanced Mean</b>	<b>66.5</b>	<b>54.6</b>	<b>5/24</b>	<b>1.62</b>	<b>2.01</b>	<b>9.79</b>

\* Hybrid variety; All others open pollinated

<sup>§</sup> 0 = no lodging, 5 = all plants lodged

## HICKORY CORNERS 2020 TRIAL DETAILS

Planting date: 10/15/19

Fertility: 10/8/19 – 32 lbs N/A, 52 lbs P/A, 12 lbs S/A:

4/3/20 - 70 lbs N/A, 10 lbs S/A

Plant Growth Regulator (Enhanced Management Only):  
4/27/20 14.4 oz/A  
Palisade EC

Fungicide (Enhanced Management Only):  
5/27/20 13.7 oz/A Miravis Ace

Harvest: 7/23/2020

Growing season conditions: April and May were cool and moist but June was warm and dry.

Research site details:

W.K. Kellogg Biological Station (KBS): Project managed by Brook Wilke, Dean Baas, Josh Dykstra, Christian Kapp

Previous crop: Soybeans

Soil type: Kalamazoo Sandy Loam



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# MSU CEREAL RYE VARIETY TRIALS

Hickory Corners, MI - 2021

Variety	Yield (bu/A)	Density (lb/bu)	Heading Date	Height (m)	Lodging (0-5) <sup>§</sup>	Biomass (Tons/Acre) on 5/24/21
<b>Normal Management</b>						
AC Hazlet	51.4	50.7	5/22	1.51	4.33	4.37
Aroostook	47.3	49.7	5/13	1.65	4.33	4.40
Danko	56.1	51.1	5/19	1.48	3.08	3.73
Elbon	37.9	51.3	5/14	1.75	3.92	4.39
FL401	32.3	49.4	5/8	1.71	4.17	3.74
Guardian	46.7	51.0	5/19	1.67	4.17	4.41
KWS Binnitto*	77.6	49.3	5/20	1.29	2.50	4.00
KWS Bono*	74.6	51.6	5/20	1.27	3.58	4.03
KWS Brassetto*	73.5	51.2	5/19	1.39	3.42	3.93
KWS Daniello*	80.5	51.2	5/19	1.38	3.21	4.11
KWS Progas*	66.2	48.1	5/20	1.48	3.83	4.19
KWS Serafino*	68.2	51.2	5/20	1.33	3.25	4.38
KWS Tayo*	90.1	51.1	5/20	1.40	3.25	3.82
Maton	36.7	50.6	5/13	1.72	4.08	4.28
Merced	40.5	50.6	5/8	1.49	4.75	3.36
ND Dylan	47.8	49.6	5/21	1.65	3.92	4.47
ND Gardner	50.5	48.8	5/14	1.70	4.25	4.65
Spooner	50.3	50.4	5/17	1.69	3.83	4.17
VNS	54.6	50.5	5/21	1.58	3.67	4.22
Wheeler	25.7	48.2	5/21	1.88	2.25	4.15
Wrens Abruzzi	44.0	51.4	5/14	1.68	4.25	4.27
<b>Mean</b>	<b>54.9</b>	<b>50.3</b>	<b>5/17</b>	<b>1.56</b>	<b>3.72</b>	<b>4.15</b>
<b>Tukey's HSD P=.05</b>	<b>28.0</b>	<b>2.3</b>		<b>0.24</b>	<b>1.75</b>	<b>1.36</b>

\* Hybrid variety; All others open pollinated

§ 0 = no lodging, 5 = all plants lodged



## HICKORY CORNERS 2021 TRIAL DETAILS

Planting date: 10/9/20

Fertility: 10/8/20– 32 lbs N/A, 52 lbs P/A, 12 lbs S/A:

3/22/21– 60 lbs K<sub>2</sub>O/A, 70 lbs N/A, 10 lbs S/A

Harvest: 7/20/21 - 7/21/21

Growing season conditions: April was average but May and early June suffered from a severe drought, followed by 10 inches of rain in the last two weeks of June.

Research site details:

W.K. Kellogg Biological Station (KBS): Project managed by Brook Wilke, Dean Baas, Josh Dykstra

Previous crop: Soybeans

Soil type: Kalamazoo Sandy Loam



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## MSU CEREAL RYE VARIETY TRIALS

Chatham, MI 2020

Variety	Yield (bu/A)	Density (lb/bu)	Heading Date	Height (m)	Lodging (0-5) <sup>§</sup>	Spring Vi-gor# (0-10)
<b>Normal Management</b>						
AC Hazlet	35.8	55.1	6/13	1.22	2.25	9.75
Aroostook	30.7	54.0	6/12	1.31	3.25	8.00
Danko	28.2	54.8	6/16	1.09	1.25	4.25
Elbon	15.8	53.8	6/13	1.24	3.00	3.00
FL401	NA	NA	NA	NA	NA	1.50
Guardian	31.4	54.1	6/14	1.26	3.25	7.75
KWS Bono*	40.6	54.7	6/16	0.92	1.50	7.25
KWS Brasetto*	39.2	54.2	6/17	1.01	1.25	5.50
KWS Serafino*	36.5	54.8	6/17	1.02	1.25	5.00
Maton	25.7	54.0	6/13	1.28	3.50	5.25
Merced	NA	NA	NA	NA	NA	1.50
ND Dylan	40.2	54.6	6/14	1.30	3.00	9.25
VNS	31.2	54.3	6/15	1.20	3.25	6.25
Wheeler	21.6	51.3	6/17	1.42	1.50	6.00
Wrens Abruzzi	32.0	55.3	6/12	1.28	3.75	5.75
<b>Normal Mean</b>	<b>31.5</b>	<b>54.2</b>	<b>6/14</b>	<b>1.20</b>	<b>2.46</b>	<b>5.73</b>
<b>Enhanced Management</b>						
AC Hazlet	53.4	56.1	6/17	1.00	1.50	9.50
Aroostook	38.5	54.8	6/15	1.16	2.75	7.50
Danko	30.9	55.1	6/18	1.02	1.25	4.25
Elbon	25.6	52.3	6/15	1.19	3.75	2.75
FL401	NA	NA	NA	NA	NA	1.75
Guardian	43.4	56.9	6/17	1.05	1.50	9.25
KWS Bono*	28.9	54.4	6/19	0.84	1.75	5.25
KWS Brasetto*	40.2	54.6	6/20	0.92	2.00	5.25
KWS Serafino*	53.4	55.9	6/16	0.81	1.25	8.25
Maton	23.1	55.0	6/15	1.25	4.00	3.00
Merced	NA	NA	NA	NA	NA	1.50
ND Dylan	49.1	55.0	6/17	1.09	2.00	9.75
VNS	38.5	55.2	6/18	1.02	2.25	6.75
Wheeler	23.5	52.6	6/20	1.23	1.00	6.25
Wrens Abruzzi	34.8	56.4	6/16	1.13	3.00	6.75
<b>Enhanced Mean</b>	<b>37.2</b>	<b>54.9</b>	<b>6/17</b>	<b>1.06</b>	<b>2.15</b>	<b>5.85</b>

\* Hybrid variety; All others open pollinated

<sup>§</sup> 0 = no lodging, 5 = all plants lodged

### CHATHAM 2020 TRIAL DETAILS

Planting date: 9/26/19

Fertility: 5/12/20 - 70 lbs N/A, 10 lbs S/A

Plant Growth Regulator (Enhanced Management Only): 6/3/20 14 oz/A Palisade EC

Fungicide (Enhanced Management Only): 7/16/20 8.2 oz/A Prosaro

Harvest: 8/25/2020

Growing season conditions: 2020 was warmer and wetter than average in the Upper Peninsula

Research site details:

Upper Peninsula Research and Extension Center (UPREC): Project managed by James DeDecker, Christian Kapp, Andrew Bahrman

Previous crop: Corn

Soil type: Eben very cobbly sandy loam



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# MSU CEREAL RYE VARIETY TRIALS

Chatham, MI - 2021

Variety	Yield (bu/A)	Density (lb/bu)	Heading Date	Height (m)	Lodging (0-5) <sup>§</sup>	Biomass (Tons/Acre) on 6/8/21
<b>Normal Management</b>						
AC Hazlet	40.7	58.1	6/4	1.10	2	0.86
Aroostook	28.1	56.8	5/27	1.25	4	0.97
Danko	23.5	57.4	6/3	1.00	1	0.56
Elbon	15.1	57.3	5/28	1.27	4	0.73
FL401	NA	NA	NA	NA	NA	NA
Guardian	37.9	58.1	6/3	1.24	3	0.84
KWS Binnitto*	63.0	55.6	6/4	1.00	1	0.81
KWS Bono*	72.2	58.0	6/3	0.95	1	0.88
KWS Brasetto*	54.8	57.4	6/3	0.94	1	0.72
KWS Daniello*	53.7	57.1	6/3	0.97	1	0.78
KWS Progas*	38.0	55.3	6/4	1.09	1	0.76
KWS Serafino*	66.2	57.9	6/3	0.95	2	0.86
KWS Tayo*	68.0	57.5	6/3	0.97	1	0.79
Maton	14.0	57.2	5/28	1.20	3	0.53
Merced	NA	NA	NA	NA	NA	NA
ND Dylan	27.9	56.5	6/5	1.11	3	0.58
ND Gardner	34.0	56.9	5/27	1.21	4	1.03
Spooner	30.1	57.5	5/30	1.10	4	0.95
VNS	30.2	56.8	6/5	1.18	2	0.60
Wheeler	17.1	53.4	6/5	1.44	1	0.78
Wrens Abruzzi	30.2	57.9	5/28	1.14	4	0.84
<b>Mean</b>	<b>39.1</b>	<b>56.9</b>	<b>6/1</b>	<b>1.11</b>	<b>2</b>	<b>0.76</b>
<b>Tukey's HSD P=.05</b>	<b>16.3</b>	<b>2.20</b>		<b>0.22</b>	<b>1.4</b>	<b>0.44</b>

\* Hybrid variety; All others open pollinated

<sup>§</sup>0 = no lodging, 5 = all plants lodged

## HICKORY CORNERS 2021 TRIAL DETAILS

Planting date: 9/23/20

Fertility: 5/10/21 - 70 lbs  
N/A, 10 lbs S/A

Harvest: 8/6/2021

Growing season conditions: 2021 was warmer and drier than average in the Upper Peninsula. FL401 and Merced winter-killed

Research site details:

Upper Peninsula Research and Extension Center (UPREC): Project managed by James DeDecker, Christian Kapp, Andrew Bahrman

Previous crop: Summer fallow

Soil type: Eben very cobbly sandy loam



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## MSU CEREAL RYE VARIETY TRIALS

Gratiot County, MI - 2020

Variety	Yield (bu/A)	Density (lb/bu)
AC Hazlet	77.8	54.5
Aroostook	63.9	53.4
Danko	80.2	53.6
Elbon	48.5	51.4
FL401	36.4	41.1
Guardian	79.6	54.1
KWS Bono*	108.0	55.9
KWS Brasetto*	103.5	55.2
KWS EXP-B*	107.4	54.7
KWS ProPower*	100.5	54.9
Maton	50.6	49.5
Merced	35.4	44.6
ND Dylan	72.8	53.9
Wheeler	42.8	50.1
Wrens Abruzzi	58.1	54.7
<b>Mean</b>	<b>71.0</b>	<b>52.1</b>

\* Hybrid variety; All others open pollinated

Yield data from Hickory Corners and Gratiot show up to a three-fold difference in average yield between the hybrid varieties and varieties typically used for cover crops or forage (e.g. Wheeler, FL401, Merced). Other open pollinated varieties that have been developed for grain production (e.g. Danko, AC Hazlet) yielded more than the lowest yielding varieties, but less than the hybrids. Furthermore, enhanced management in Hickory Corners influenced the hybrid variety characteristics but not the open pollinated varieties.

Data from the Chatham location show a slightly different trend. Grain yields were lower overall compared to the other sites. The hybrid varieties yielded similar to the higher producing open pollinated varieties in 2020, while most hybrids yielded higher than the open pollinated varieties in 2021. Two varieties (FL401 and Merced) did not survive the winter at Chatham. Enhanced management at Chatham also had a larger overall impact on yield and plant characteristics compared to the Hickory Corners site.

**Grain quality, spirit yield, and sensory analyses** have been completed on the varieties grown in Hickory Corners, Gratiot and Chatham, reported in the pages below. We found higher concentrations of 4-vinyl guaiacol (4-VG) in distillate from grain grown at Chatham vs. Hickory Corners, a strong negative relationship between protein and spirit yield (2020 and 2021), a positive relationship between 4-VG and protein (2020 only) and a positive relationship between ferulic acid and 4-VG (2021 only).

## GRATIOT COUNTY TRIAL DETAILS

Planting date: 10/20/19

Fertility: 10/19/19 – 20 lbs N/A, 80 lbs P/A, 80 lbs K/A:

3/17/20 - 90 lbs N/A, 15 lbs S/A

Fungicide: 5/22/20 8.0 oz/A Delaro, 6/8/20 8.0 oz/a Prosaro + NIS

Harvest: 7/22/2020

Research site details:

Crumbaugh Legacy Farms near Breckenridge, MI. Rye was planted adjacent to the MSU Wheat Performance Trials

Previous crop: Soybeans

Soil type: Parkhill loam, 0 to 1 percent slopes



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## MSU CEREAL RYE VARIETY TRIALS – 2020 QUALITY

### Protein

	HC	CH	GR	Average
Variety	Protein (%)	Protein (%)	Protein (%)	Protein (%)
FL401	12.5		15.7	<b>14.1</b>
Merced	10.9		16.1	<b>13.5</b>
Wheeler	12.6	13.8	14.1	<b>13.5</b>
Maton	11.3	13.3	13.6	<b>12.7</b>
Elbon	11.5	12.5	13.2	<b>12.4</b>
Aroostook	10.4	12.4	12.0	<b>11.6</b>
Wrens Abruzzi	10.5	12.2	12.0	<b>11.6</b>
Guardian	9.2	11.3	10.5	<b>10.3</b>
Danko	8.8	11.1	10.7	<b>10.2</b>
VNS	9.1	11.2		<b>10.2</b>
AC Hazlet	8.9	11.3	9.9	<b>10.0</b>
ND Dylan	8.9	10.9	10.1	<b>10.0</b>
KWS ProPower*			9.7	<b>9.7</b>
KWS Bono	8.2	10.0	9.3	<b>9.2</b>
KWS Brassetto*	8.0	10.3	9.2	<b>9.2</b>
KWS-EXP-B*			8.9	<b>8.9</b>
KWS Serafino*	7.7	9.5		<b>8.6</b>
<b>Mean</b>	<b>9.9</b>	<b>11.5</b>	<b>11.7</b>	<b>10.9</b>

### Spirit Yield

	HC	CH	GR	Average
Variety	Spirit Yield LAA/tonne	Spirit Yield LAA/tonne	Spirit Yield LAA/tonne	Spirit Yield LAA/tonne
KWS Bono	387	375	374	<b>378.7</b>
KWS Serafino*	381	370		<b>375.5</b>
AC Hazlet	384	367	370	<b>373.7</b>
VNS	380	366		<b>373.0</b>
KWS-EXP-B*			372	<b>372.0</b>
Danko	380	365	366	<b>370.3</b>
KWS ProPower*			369	<b>369.0</b>
Guardian	380	361	364	<b>368.3</b>
KWS Brassetto*	379	360	366	<b>368.3</b>
ND Dylan	376	365	361	<b>367.3</b>
Aroostook	365	357	351	<b>357.7</b>
Wrens Abruzzi	371	350	351	<b>357.3</b>
Elbon	358	351	346	<b>351.7</b>
Wheeler	358	352	343	<b>351.0</b>
Maton	360	350	342	<b>350.7</b>
Merced	362		330	<b>346.0</b>
FL401	352		327	<b>339.5</b>
<b>Mean</b>	<b>372</b>	<b>361</b>	<b>355</b>	<b>363</b>

\* Hybrid variety; All others open pollinated

Sites: HC = Hickory Corners, CH = Chatham, GR = Gratiot County

## GRAIN QUALITY

Cereal rye intended for distilling has two primary quality metrics of interest; spirit yield and flavor. These metrics were analyzed through a partnership with the Hartwick Center for Craft Beverage.

The Predicted Spirit Yield represents the maximum theoretical alcohol production potential of the grain on a per weight basis. The units are Litres of Absolute Alcohol (at 200° Proof) per metric tonne.



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## MSU CEREAL RYE VARIETY TRIALS – 2020 QUALITY

### Flavor (4-VG)

Variety	HC 4-VG (mg/L)	CH 4-VG (mg/L)	GR 4-VG (mg/L)	Average 4-VG (mg/L)
FL401	5.9		9.0	7.5
Wheeler	5.5	7.7	6.1	6.4
Merced	5.7		6.9	6.3
Maton	4.3	6.8	6.2	5.8
AC Hazlet	4.5	7.1	5.4	5.7
Elbon	5.3	5.8	5.9	5.7
Wrens Abruzzi	5.1	6.2	5.5	5.6
Aroostook	5.0	6.2	5.4	5.5
Guardian	5.2	6.0	5.1	5.4
VNS	4.4	6.1		5.3
ND Dylan	4.9	5.8	5.0	5.2
KWS Serafino*	4.2	5.7		5.0
Danko	3.9	6.4	4.4	4.9
KWS Brassetto*	4.0	5.5	4.5	4.7
KWS ProPower*			4.7	4.7
KWS Bono	3.6	5.1	3.8	4.2
KWS-EXP-B*			4.1	4.1
<b>Mean</b>	<b>4.8</b>	<b>6.2</b>	<b>5.5</b>	<b>5.4</b>

\* Hybrid variety; All others open pollinated

Sites: HC = Hickory Corners, CH = Chatham, GR = Gratiot County

## GRAIN QUALITY

The desirable 'spicy' aroma characteristic of rye spirits stems from certain phenolic compounds. In particular, this is from 4-vinyl guaiacol (4-VG) is produced by yeast by the metabolism of ferulic acid (FA), which is abundant in rye grain.

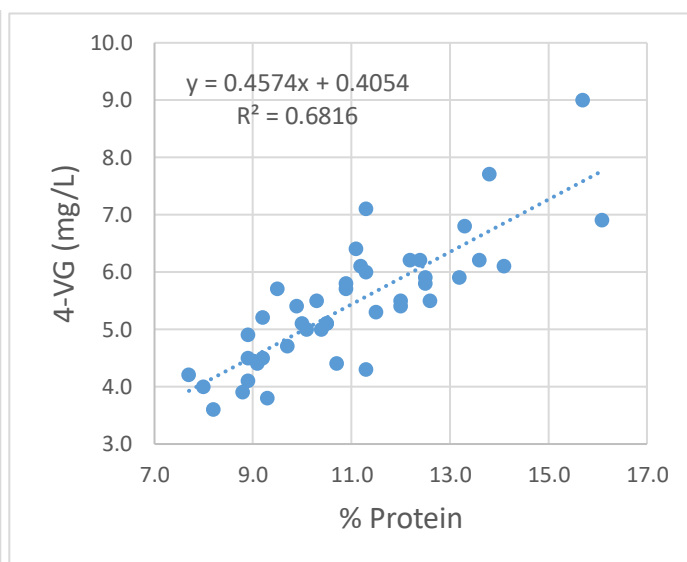
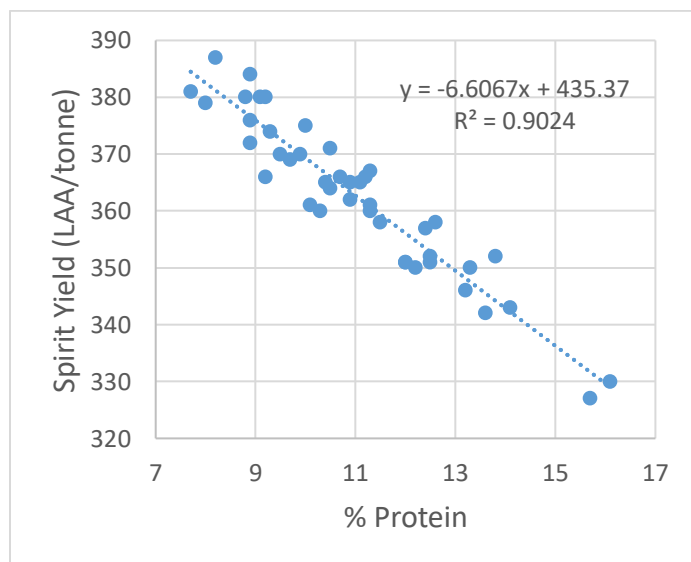


Figure 1. Using each site and variety from 2020 as an individual data point, a negative relationship was evident between spirit yield and protein, but a positive relationship between 4-VG and protein. These relationships indicate that protein analysis can be useful in predicting spirit yield and flavor compounds.

# MSU CEREAL RYE VARIETY TRIALS – 2021 QUALITY

## Protein and Spirit Yield

Variety	HC	CH	HC	CH
	Protein (%)	Protein (%)	Spirit Yield LAA/tonne	Spirit Yield LAA/tonne
AC Hazlet	10.2	10.3	381	383
Aroostook	13.5	11.1	356	360
Danko	10.9	10.6	363	372
Elbon	13.7	13.2	357	353
FL401	14.9		346	
Guardian	10.7	10.1	368	375
KWS Binnitto*	10.1	8.4	365	379
KWS Bono*	10.2	9	372	383
KWS Brasetto*	9.6	8.7	363	375
KWS Daniello*	9.3	9.1	376	378
KWS Progas*	12.3	11	357	370
KWS Serafino*	10.1	8.3	365	382
KWS Tayo*	9.3	8.2	372	376
Maton	13.9	13.5	358	351
Merced	13.6		354	
ND Dylan	11.4	10.6	363	360
ND Gardner	12.6	10.2	357	361
Spooner	11.2	10.2	365	369
VNS	11.1	10.8	371	374
Wheeler	15.7	15.1	350	350
Wrens Abruzzi	12.8	12.3	362	362
<b>Mean</b>	<b>11.5</b>	<b>10.6</b>	<b>364</b>	<b>369</b>

\* Hybrid variety; All others open pollinated

Sites: HC = Hickory Corners, CH = Chatham

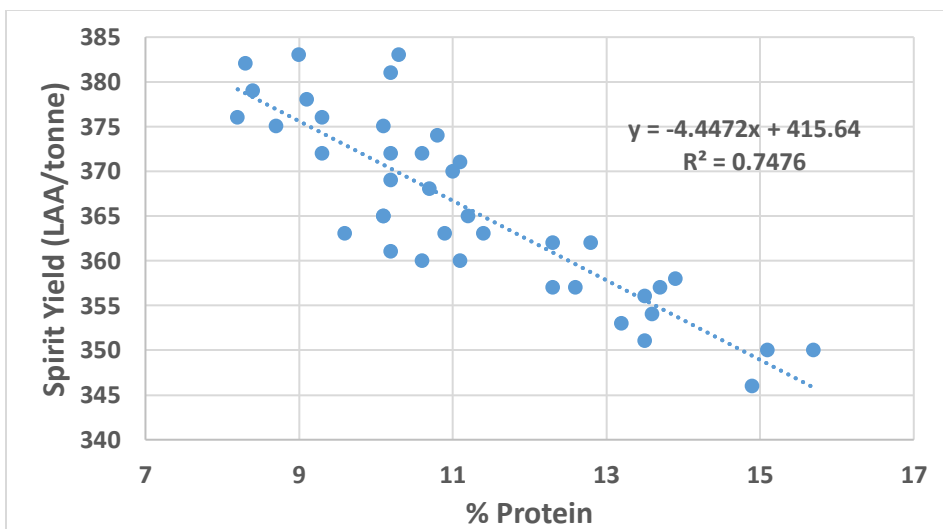


Figure 2. Using each site and variety from 2021 as an individual data point, a negative relationship was evident between spirit yield and protein, which was consistent with data from 2020.

## GRAIN QUALITY

Cereal rye intended for distilling has two primary quality metrics of interest; spirit yield and flavor. These metrics were analyzed through a partnership with the Hartwick Center for Craft Beverage.

The Predicted Spirit Yield represents the maximum theoretical alcohol production potential of the grain on a per weight basis. The units are Litres of Absolute Alcohol (at 200° Proof) per metric tonne.





## MSU CEREAL RYE VARIETY TRIALS – 2021 QUALITY

### Flavor (Ferulic Acid & 4-VG)

Variety	HC	CH	HC	CH
	Ferulic Acid (mg/L)	Ferulic Acid (mg/L)	4-VG (mg/L)	4-VG (mg/L)
AC Hazlet	3.04	7.32	5.37	7.52
Aroostook	3.74	7.55	5.63	9.77
Danko	0.08	6.38	4.58	8.35
Elbon	1.03	8.12	5.94	10.15
FL401	0.55		5.49	
Guardian	3.91	7.26	7.42	8.34
KWS Binnitto*	3.42	6.46	7.43	7.38
KWS Bono*	2.01	5.72	4.88	7.18
KWS Brasetto*	4.11	6.91	5.30	8.66
KWS Daniello*	2.69	6.60	6.14	7.16
KWS Progas*	5.53	6.82	6.31	7.97
KWS Serafino*	1.00	6.96	7.21	8.04
KWS Tayo*	5.99	5.94	7.16	6.88
Maton	4.17	8.26	6.11	10.48
Merced	4.62		5.75	
ND Dylan	6.47	7.05	7.30	9.55
ND Gardner	5.88	7.43	6.64	9.02
Spooner	5.48	6.33	5.71	7.72
VNS	7.39	8.16	8.09	9.54
Wheeler	5.41	10.79	8.24	12.33
Wrens Abruzzi	8.23	7.33	8.30	8.47
<b>Mean</b>	<b>4.21</b>	<b>7.23</b>	<b>6.49</b>	<b>8.66</b>

\* Hybrid variety; All others open pollinated

Sites: HC = Hickory Corners, CH = Chatham

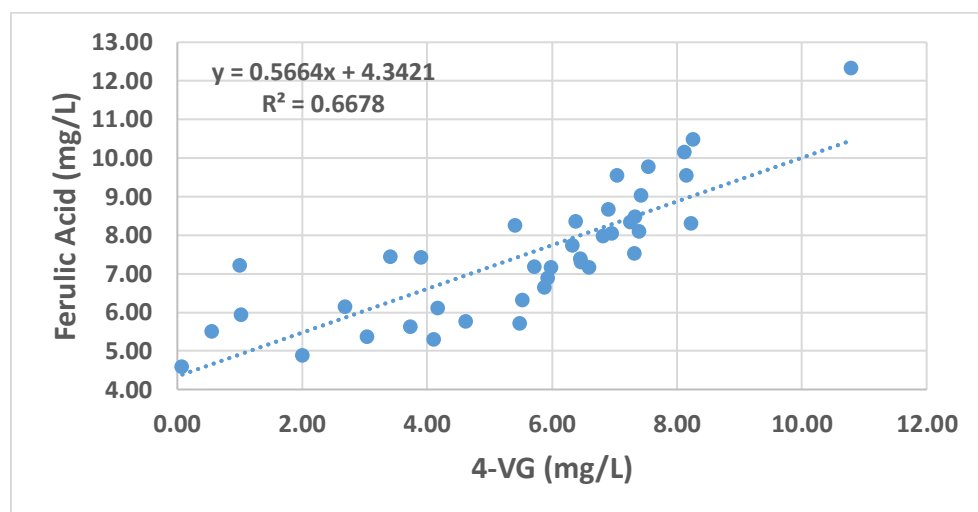


Figure 3. Using each site and variety from 2021 as an individual data point, a linear positive relationship existed between ferulic acid and 4-VG. This relationship is expected since ferulic acid is a precursor to 4-VG. No relationship between Protein (%) and 4-VG or Ferulic Acid was present in the 2021 dataset.

## GRAIN QUALITY

The desirable 'spicy' aroma characteristic of rye spirits stems from certain phenolic compounds. In particular, this is from 4-vinyl guaiacol (4-VG) is produced by yeast by the metabolism of ferulic acid (FA), which is abundant in rye grain.

Across both years, rye grown in Chatham had lower yields but higher average ferulic acid and 4-VG concentrations compared to Hickory Corners.

