

## PROGRESS REPORT ON GRASS SEED PRODUCTION RESEARCH

prepared by

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### Grass-Legume Seed Institute Presentation

**Roseau, MN - March 1, 2023**

This summary and previous annual research summaries are on the Web at:

**<https://turf.umn.edu/seed-production-research-progress-reports>**

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## **Standard Management Practices for University of Minnesota Grass Seed Production Research Plots**

### ***General management regime of perennial ryegrass plots on the Magnusson Research Farm:***

#### **Spring seeded ryegrass with wheat-BMP(best management practice)**

Ryegrass seeded at 5#/acre with spring wheat  
Sterling Blue(dicamba)+ 2,4-D amine 4 (0.75 + 0.75 pint) applied in mid-September  
Fertilize 30-30-30 mid-September after small grain harvest  
Spike tooth harrow after fall fertilizer application to spread straw  
Fertilize 110-0-0 applied early to mid-May, 300 - 600 GDD  
Sterling Blue+ 2,4-D amine 4 (0.75+0.75 pint) applied late May, 700 - 900 GDD  
Tacoma or Assure II (8-10 oz) applied early June, 800 - 1,000 GDD  
Apogee (6-8 oz) applied early heading, 1,100 - 1,300 GDD  
Priaxor 6oz. applied full heading, 1,700 - 1,900 GDD

#### **Fall seeded ryegrass in wheat stubble**

Pre-harvest glyphosate application to wheat , or  
glyphosate applied to wheat stubble prior to seeding ryegrass.  
Ryegrass seeded at 6#/acre after wheat harvest into existing stubble  
No broadleaf application in fall but other management for fall seeded ryegrass the same as spring seeded.  
If planted into summer fallow, no additional nitrogen is added.

#### **Tall Fescue**

Establishment=Seed at 7#/acre under spring wheat in May.  
60-50-50-10s September after wheat harvest and 80-0-0 early May.  
.75pt. 2,4-D a + .75pt. Sterling Blue late September.  
Bale off straw after harvest and clip 4"+ bale remaining residue in mid September.

#### **Kentucky bluegrass**

Establishment=Seed at 4#/acre in late August to early September.  
120-40-40-10s applied in late September.  
.75pt. 2,4-D a + .75pt. Sterling Blue late September.  
Field burn in early August.

#### **General seed harvest procedure for small research plot**

Measured areas are hand cut and bagged for each individual plot.  
These samples are then brought to the U of M St.Paul campus  
where they are dried, threshed, cleaned and weighed.  
Seed yields, quality and other data are statistically analyzed and results summarized.

#### **On-farm small plot research trials**

General crop management is done by the grower/cooperator.  
Application of treatment variables, agronomic notes and harvest by University of Minnesota personnel.  
Cooperators asked to avoid applications of treatments involved in the study to the research plot area.

#### **On-farm large plot trial research protocol**

These experiments are conducted in fields with growers implementing all of the general field management.  
Treatment variables are field scale and are applied either by the grower or University personnel.  
University agronomists and grower cooperators work together to insure treatment variables are properly applied.  
Plant samples, crop development observations and other applicable notes  
are recorded as needed throughout the growing season usually by University personnel.  
At harvest, University agronomists will assist the growers in collecting quality samples and recording harvest data.  
Experimental design usually consists of 2 or 3 treatment variables and 3 replicates/treatment.

#### **2022 Research Locations**

MagPlots=University of Minnesota-Magnusson Research Farm 2 miles north and 4.5 miles west of Roseau,Mn  
MagFarms=Magnusson Farms- NW of Roseau  
Brateng Farm= South of Roseau  
Rice Farms= NW of Roseau  
Estling Farm=North of Roosevelt  
Stanley Farms=Grygla area

Table 1.

**Monthly and Year End Precipitation Totals\***  
**Roseau, Mn 1967-2022.**

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Yearly Total(in.)	Mean Deviation	Mean(F <sup>o</sup> )
1967	1.13	0.39	0.59	2.89	0.89	2.23	4.95	1.69	0.83	1.11	0.70	1.76	19.16	-3.52	35.8
1968	0.62	T	1.25	0.63	1.46	6.47	6.13	8.49	2.35	1.26	1.06	0.21	29.93	7.25	37.3
1969	3.07	0.11	0.05	1.27	3.31	2.29	3.70	4.28	3.29	1.91	0.30	0.73	24.31	1.63	37.0
1970	0.71	0.41	1.38	2.56	5.93	4.07	3.55	0.83	2.77	1.49	1.21	0.37	25.28	2.60	35.0
1971	0.54	0.13	0.26	1.50	2.24	2.29	3.58	0.69	3.33	2.97	0.29	0.50	18.32	-4.36	36.2
1972	0.68	0.76	0.50	0.70	1.66	5.03	1.92	1.53	4.22	1.40	0.38	0.32	19.10	-3.58	34.9
1973	0.09	0.17	1.18	0.90	2.46	2.21	4.04	2.09	5.67	1.19	0.67	0.75	21.42	-1.26	M
1974	0.88	0.87	0.16	2.72	4.12	1.56	2.56	11.00	0.42	0.66	0.15	1.40	26.47	3.79	M
1975	1.10	0.29	0.64	1.40	1.52	4.96	2.26	1.75	1.79	1.49	0.20	0.65	18.05	-4.63	M
1976	1.13	0.50	1.05	0.77	0.54	5.82	1.52	3.72	0.34	0.07	T	0.37	15.83	-6.85	36.2
1977	0.14	0.62	1.02	0.27	2.43	3.71	2.28	1.74	3.83	0.87	2.27	0.26	19.44	-3.24	37.7
1978	0.36	0.26	0.17	1.00	1.97	1.92	6.25	3.25	3.44	0.23	0.98	0.79	20.62	-2.06	35.3
1979	0.50	1.01	1.06	2.77	1.89	1.91	3.70	1.59	0.45	1.40	1.02	0.16	17.46	-5.22	32.6
1980	0.55	0.82	0.35	0.00	0.24	1.75	3.35	5.19	4.12	1.66	0.94	0.18	19.15	-3.53	36.0
1981	0.27	0.16	0.66	0.56	2.79	6.85	2.63	2.41	3.63	1.75	0.90	0.99	23.60	0.92	38.3
1982	1.30	0.45	0.74	0.24	1.38	2.00	5.53	2.71	1.92	2.91	0.46	0.57	20.21	-2.47	34.2
1983	1.31	1.26	1.17	0.53	2.76	4.03	1.62	3.34	2.91	2.26	0.66	0.10	21.95	-0.73	37.7
1984	T	0.95	T	0.72	0.72	4.46	3.78	0.99	0.37	4.32	0.10	1.02	17.43	-5.25	37.3
1985	0.12	0.33	0.06	1.07	4.35	4.62	1.08	8.72	1.60	1.04	1.68	0.38	25.05	2.37	34.4
1986	0.30	0.90	0.26	2.96	1.40	2.43	3.59	2.04	2.52	0.65	1.97	0.36	19.38	-3.30	M
1987	0.47	0.30	0.10	0.59	4.37	2.25	4.80	2.22	0.82	0.92	0.73	0.35	17.92	-4.76	M
1988	0.60	0.09	1.75	0.00	1.74	1.34	5.53	1.70	2.24	0.12	0.77	1.05	16.93	-5.75	M
1989	3.27	0.32	2.86	0.10	2.82	5.46	1.60	2.56	1.24	0.41	0.62	0.45	21.71	-0.97	M
1990	0.55	0.20	1.12	1.09	0.46	3.19	2.48	0.62	0.91	0.16	0.18	0.72	11.68	-11.00	38.2
1991	0.56	0.64	0.58	2.87	3.19	5.94	3.40	1.99	7.42	1.64	1.36	0.70	30.29	7.61	M
1992	0.61	0.68	0.45	2.27	1.99	2.36	2.72	4.51	2.76	0.12	1.27	0.88	20.62	-2.06	36.5
1993	0.68	0.05	0.27	1.01	1.63	5.06	5.87	4.69	0.72	0.71	0.45	0.65	21.79	-0.89	35.5
1994	0.21	0.33	0.47	0.02	0.16	2.54	3.03	3.48	3.94	1.38	2.72	0.32	18.60	-4.08	37.7
1995	0.57	0.59	1.23	0.61	2.50	2.13	4.59	3.59	1.81	1.33	1.54	1.46	21.95	-0.73	35.8
1996	0.94	0.48	0.22	1.65	4.62	1.64	7.34	1.78	1.77	1.75	2.73	1.07	25.99	3.31	M
1997	1.06	0.14	1.02	0.84	2.02	3.36	4.02	1.31	4.01	2.45	0.19	0.25	20.67	-2.01	M
1998	0.69	1.05	0.21	0.77	4.55	5.39	3.01	2.20	0.31	4.42	1.39	0.95	24.94	2.26	M
1999	0.15	0.77	0.23	1.31	4.09	6.97	3.46	1.38	3.16	0.43	0.38	0.56	22.89	0.21	40.1
2000	0.45	0.14	0.79	0.38	1.83	7.38	1.63	6.45	2.14	2.89	3.41	0.74	28.23	5.55	38.2
2001	0.21	0.52	0.46	1.89	3.27	1.76	4.74	1.40	0.72	1.76	1.50	0.56	18.79	-3.89	39.8
2002	0.19	0.10	0.45	1.44	2.79	9.94	2.96	4.47	1.62	1.02	0.30	0.54	25.82	3.14	38.1
2003	0.80	0.77	1.60	1.75	2.95	3.56	1.92	1.78	4.55	1.32	1.52	1.95	24.47	1.79	37.6
2004	2.85	0.70	2.14	2.61	8.19	2.98	2.42	5.50	2.97	2.36	0.08	1.33	34.13	11.45	36.0
2005	2.33	0.67	0.82	0.73	3.62	7.55	3.37	3.24	1.77	3.48	2.06	1.65	31.29	8.61	39.0
2006	2.52	0.95	1.01	1.23	1.97	1.00	0.94	2.18	2.42	1.54	0.17	0.56	16.49	-6.19	41.0
2007	0.44	0.56	1.25	0.95	2.75	7.75	2.92	1.37	0.92	5.14	0.39	0.86	25.30	2.62	38.0
2008	0.25	1.29	0.46	2.17	1.56	3.93	4.33	3.63	3.06	2.37	2.00	1.47	26.52	3.84	36.0
2009	1.25	1.75	4.45	1.37	3.59	3.72	1.28	3.92	2.67	1.06	0.28	1.22	26.56	3.88	36.0
2010	0.80	0.43	0.55	1.23	6.47	2.88	3.79	1.50	6.09	2.42	1.14	0.61	27.91	5.23	40.0
2011	1.15	0.20	0.23	3.14	2.63	3.87	2.38	1.63	0.89	1.34	0.19	0.07	17.72	-4.96	39.0
2012	0.59	1.06	2.06	1.39	1.48	3.32	2.74	1.42	0.18	3.64	1.22	0.24	19.10	-3.58	41.0
2013	1.34	1.21	1.05	1.40	4.69	1.70	2.14	3.77	2.65	0.84	1.43	1.85	24.07	1.39	35.0
2014	2.32	0.54	3.31	1.71	3.74	4.23	2.21	1.62	2.68	1.14	0.75	1.49	25.74	3.06	36.0
2015	1.11	0.57	0.71	0.42	5.18	4.33	6.27	4.45	1.43	2.08	1.52	3.08	31.15	8.47	41.0
2016	0.39	0.89	1.31	1.29	3.14	5.71	3.57	1.23	3.97	0.97	0.85	0.75	24.07	1.39	42.0
2017	1.44	1.55	0.59	0.47	0.90	5.55	0.83	0.99	6.22	0.97	0.94	2.71	23.16	0.48	41.2
2018	1.04	0.99	2.76	0.02	2.71	1.89	1.75	1.36	2.05	1.68	0.62	1.28	18.15	-4.53	36.6
2019	0.90	1.65	1.66	0.27	1.42	2.99	4.09	3.42	9.95	4.18	0.80	0.74	32.07	9.39	35.2
2020	0.84	0.29	1.30	0.53	1.66	6.29	8.23	2.30	0.77	1.11	1.19	0.99	25.50	2.82	38.3
2021	0.35	0.23	0.14	1.32	1.64	1.53	1.18	3.52	1.18	3.00	2.07	1.50	17.66	-5.02	42.1
2022	0.54	1.88	0.33	3.45	5.27	2.07	3.54	5.86	1.94	0.91	0.66	1.31	27.76	5.08	36.0
<b>53 year average annual precipitation</b>													<b>22.68</b>		
														51 year available mean temperature=	37.2

\*Precipitation amounts used are from the Magnusson Research Farm-near Roseau April/May-October and Minnesota Climatology Working Group nearest location or Fox NDAWN for the remainder of the year. Average precipitation the last 20 years=24.94". Average precipitation the previous 33 years=21.16"



Table 4.

**2020 Kentucky Bluegrass Variety Trial  
Magnusson Research Farm-Roseau,Mn**

LINE	source	MSP#	Seed Yield		Harvest		Heading (%)				
			#/ac	% of mean	Ht.(in.)	Date	5/31	6/4	6/8	6/13	6/17
318west	UM	4120	<b>429</b>	68	24	21-Jul	0	T	2	23	40
610middle*	UM	4121*	<b>354</b>	56	24	21-Jul	0	3	9	18	33
704east*	UM	4122*	<b>427</b>	68	24	21-Jul	0	4	11	23	35
A99-3124	MN-Rutgers	3920	<b>445</b>	70	24	21-Jul	0	T	7	20	35
Minnfine	check	4063	<b>736</b>	116	31	7-Jul	5	45	75	100	100
Park	check	4062	<b>857</b>	136	29	7-Jul	3	18	58	93	100
Dragon	check	4131	<b>825</b>	131	27	12-Jul	0	T	13	65	91
Exp#1	exp	4132	<b>952</b>	151	26	12-Jul	0	8	13	48	78
Desert Moon	PST	4135	<b>705</b>	112	24	14-Jul	0	0	3	35	65
New Moon	PST	4136	<b>594</b>	94	26	14-Jul	0	5	16	50	80
LSD @5% level			<b>100</b>	<b>15</b>	3	2	1	11	12	12	10
CV(%)			11	11	10	3	102	90	40	17	10

Experimental design:RCB with 4 reps

Seeded 8/5/2020 @5#/acre

\*Significant off type contamination of these lines

Mean trial yield= 632#/acre

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Table 5.

**2019 Fine Fescue Seed Production Variety Trial  
Magnusson Research Farm-Roseau,Mn. 2022 data +2021-2 Seed Yield.**

Variety	Fescue species	Seed Lot#	Seed Yield(#/acre)				Harvest Ht.(in.)	Heading (%)			
			2022	2021	2020	3yr.ave		5/31	6/4	6/8	6/14
MN-HD	Hard	4065	269	1128	906	<b>767</b>	20	5	43	63	88
SPHD	Hard	2	167	1006	765	<b>646</b>	18	5	45	68	88
Beacon	Hard	3	80	690	699	<b>489</b>	21	T	25	55	90
Gladiator	Hard	4	109	467	579	<b>385</b>	21	3	30	55	90
Jetty	Hard	5	131	959	681	<b>590</b>	21	2	23	55	90
Radar	Chewings	6	776	788	661	<b>742</b>	29	T	16	45	80
Chantilly	St.creeping	7	116	58	402	<b>192</b>	23	0	T	8	40
LSD @ 5% level			84	209	103	<b>87</b>	1	3	12	14	6
CV(%)			24	19	10	11	4	95	33	18	5
Trial mean by year			235	728	670						

Experimental design:RCB with 4 reps

Planted 5/10/2019 with no companion crop @6#/acre

All plots harvested 7/11/2022

Table 6.

**2017 Intermediate Wheatgrass-Kernza Variety Trial****Magnusson Research Farm-Roseau,Mn. 2022 data and 2018-2022 Seed Yield**

trt#	Variety	Seed Yield-#/ac					Mean	Harvest		% heading			
		2018	2019	2020	2021	2022		lodging <sup>2</sup>	Ht.(in.)	6/22	6/26	7/1	7/6
4	MN-Clearwater	734	917	792	888	<b>1046</b>	<b>875</b>	1.0	59	23	50	80	97
5	MN1505-Syn 2	670	910	832	901	<b>930</b>	<b>849</b>	1.5	60	25	60	80	96
2	MN1502-Syn 2	512	848	881	863	<b>883</b>	<b>797</b>	1.3	62	18	60	85	97
3	MN1503-Syn 2	558	770	857	906	<b>954</b>	<b>809</b>	1.8	60	13	48	78	96
11	2015 C4	725	761	541	948	<b>890</b>	<b>773</b>	2.0	61	18	63	85	98
8	2016 C5	496	757	685	823	<b>828</b>	<b>718</b>	2.0	60	16	48	88	98
7	2016 C4	558	774	498	874	<b>914</b>	<b>724</b>	2.8	59	23	55	88	98
9	2016 3471 Selfs	514	721	472	781	<b>757</b>	<b>649</b>	3.5	60	11	50	83	96
6	2016 C3	501	705	363	719	<b>828</b>	<b>623</b>	3.0	60	20	50	85	97
10	Lot # SFD - 12 - Thin 6 - 4-10	625	670	242	683	<b>438</b>	<b>531</b>	5.5	57	7	38	73	93
1	MN1501-Syn 2	554	554	267	710	<b>683</b>	<b>554</b>	3.0	60	11	45	73	94
12	Rush	483	374	138	476	<b>305</b>	<b>355</b>	6.3	55	9	35	65	90
	LSD @ 5% Level	154	86	78	165	<b>133</b>	<b>67</b>	1.1	4	9	12	9	4
	CV(%)	18	8	10	14	<b>11</b>	<b>6</b>	28	5	40	17	8	3
	Mean yield by year	484	730	547	798	788							
	Mean Top 4 yield	519	861	841	911	961							

Experimental design:RCB with 4 reps

Seeded 8/15/2017 @ 10#/acre

Harvest Dates=8/23/22, 8/10/2021, 8/20/2020, 8/21/2019 &amp; 8/23/2018

**Crop Management-**

Fertilizer application= 140-40-40-10s applied annually in October starting in 2018.

Residue management= Chop/bale off 9/2018. Burn after harvest 9/2019, 20, 21, &amp; 22.

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table 7.

**2020 Intermediate Wheatgrass-Kernza Variety Trial****Magnusson Research Farm-Roseau,Mn. 2022 data and 2021-2022 Seed Yield**

Seed lot#	Variety	Seed Yield-#/acre			Ht.(in.)		% heading			
		2021	2022	Mean	Harvest	Hulled % <sup>1</sup>	6/22	6/26	7/1	7/6
4138	TLI 701	997	<b>1335</b>	<b>1166</b>	60	84	14	55	78	97
4139	TLI 702	955	<b>1141</b>	<b>1048</b>	58	89	23	68	90	99
4140	TLI 703	1068	<b>1144</b>	<b>1106</b>	61	75	23	60	85	98
4141	TLI 704	1108	<b>1037</b>	<b>1072</b>	61	89	11	63	85	97
4146	TLI -C5	1001	<b>1079</b>	<b>1040</b>	64	65	14	58	88	98
4142	MN-1601	948	<b>943</b>	<b>946</b>	63	70	7	43	83	98
4143	MN-1603	1012	<b>930</b>	<b>971</b>	58	68	4	30	68	88
4144	MN-1605	872	<b>981</b>	<b>927</b>	62	61	8	60	80	97
4145	MN-1607	1084	<b>939</b>	<b>1011</b>	64	61	4	35	70	93
4147	MN-Clearwater	1001	<b>1099</b>	<b>1050</b>	62	75	11	53	85	98
	LSD @ 5% Level	145	<b>140</b>	<b>97</b>	4	8	7	13	7	3
	CV(%)	10	9	6	5	7	41	24	6	2

Experimental design:RCB with 4 reps

All harvested 8-23-2022

Planted 8-20-2020 @ 10#/acre

<sup>1</sup>Hulled %= visual estimate of % hulled seed after threshing and cleaning<sup>2</sup>Lodging-1=upright;9=flat

Fertilizer application= 140-40-40-10s 10/2021

Residue burned 8/25/2021

Table 8.

**2022 Field Pea Variety Trial****Magnusson Research Farm. 2022 data and 2019-2022 grain yield**

Variety	Yield Bu/acre <sup>1</sup>				%	Harvest		50% Flower	Bushel Wt.
	2022	2021*	2020*	2019		ht(in)	Lodging <sup>2</sup>		
1 AAC Chrome	<b>119.3</b>	58.5	NA	NA	22.1	38.0	3.0	14-Jul	64.9
2 AAC Profit	<b>108.0</b>	48.5	36.2	108	24.4	40.0	1.7	15-Jul	65.0
3 Spider	<b>104.7</b>	46.2	24.5	96	22.7	41.0	5.0	13-Jul	64.4
4 Salamanica	<b>75.0</b>	49.8	36.6	96	22.9	38.0	1.0	12-Jul	62.5
LSD @ 5% Level	<b>9.0</b>	14.1	14	11	0.7	NS	2.0	1.0	0.9
CV(%)	<b>5</b>	16	34	7	2	5	37	4	1

Experimental Design: RCB w/3 reps

\*Flooding in 2020 and drought in 2021 may have reduced yields.

<sup>1</sup>Yield=Bushels per acre at 12% moisture.

<sup>2</sup>Lodging 9=Flat;1=upright

**Management-**

Herbicide application-

Authority Elite 1.5pt.acre applied immediately after planting .

Site= Conventional tillage seedbed- Non-irrigated

Fertility application 8-40-40 Soil type- sandy loam

Previous crop- spring wheat

Planting Date= 5/28/2022

Harvest date- Field Peas- 9/2/2022

Field pea Seeding Rate= 350,000PLS/acre

Table 9.

## 2021-22 Perennial Ryegrass Fertility Trial Magnusson Research Farm-Roseau,Mn

TRT# *	Total	Seed Yield	Stand <sup>1</sup>	6/17/2022		Harvest		
	N level	#/acre		RCI <sup>2</sup>	Color <sup>3</sup>	Date	Lodging <sup>4</sup>	Ht(in.)
1	0-0-0	380	3.3	147	2.7	8-Aug	1.3	17
2	140+0+0	1172	5.3	208	4.0	11-Aug	1.7	19
3	140+40+0	1613	5.7	243	5.3	9-Aug	2.0	20
7	140+0+0+20s	1789	7.0	499	9.0	6-Aug	2.0	20
	LSD @5% level	236	2.3	71	0.9	NS	NS	2
	CV(%)	9	21	13	9	36	31	4

Experimental Design:RCB w/4reps \* Variety=Arctic Green

Perennial ryegrass spring seeded 5/2021 under wheat.

\* Only 3 replications harvested on selected plots.

Stands of other treatments were too variable to harvest.

Trt#	Total #N Season	Treatment applications and timing	Treatment Explanation
1	8	8-40-40	No added N
2	140	30-0-0 on 10/19 + 95 -0-0 on 5/10	30#N oct- STANDARD- BMP
3	140	30-0-0 on 10/19 + 95-40-0 on 5/10	Standard + 0-40-0 spring
7	140	30-0-0-20s on 10/19 + 95 -0-0 on 5/10	30#N oct + 20# sulfur Oct(82#AMS)

**All plots received 8-40-40 9/1/2021**

fall treatments-10-19-2021

TRT#2 - Standard application= 30#N on 10/19/2021

and remaining 110#N on 5/10/2022.

10/19/21 Soil test results

Depth	Olsen P	K	% OM	PH	NO3-N
0-6"	16 ppm	98 ppm	2.9	8.2	8 ppm
6-24"					16 ppm

<sup>1</sup>Visual Stand Rating- 1=poor stand;9=full stand

<sup>2</sup>RCI-Relative Chlorophyll Index-higher number= more chlorophyll

<sup>3</sup>Color-1=light green;9=dark green

<sup>4</sup>Lodging-1=upright; 9=flat



Table 10.

## 2011-22 Perennial Ryegrass Fertility Trial Seed Yield Summaries Magnusson Research Farm-Roseau,Mn

Trt. #	Nitrogen Fertilizer	Nitrogen Timing	Overall <sup>3</sup> Mean	Seed Yield as % of Mean											
				2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011
1	0	0	29	25	26	24	20	21	45	38	29	27	28	21	36
2	100+0+0	Split <sup>1</sup>	98	----	91	99	103	90	104	90	----	92	96	112	108
3	140+0+0	Split <sup>1</sup>	107	77	104	104	111	101	99	110	99	104	104	118	118
4	140+40+0	Split <sup>1</sup> +(0-40-0spring)	108	106	99	96	100	107	106	109	127	120	----	----	----
5	140+0+0+20s	Split <sup>2</sup>	101	117	104	95	99	101	102	----	----	110	99	----	----
6	140+0+0	Split <sup>1</sup> +(90spring+20liq)	103	----	----	98	102	101	99	----	----	106	109	----	----
7	180+0+0	Split <sup>1</sup>	109	----	----	----	----	107	92	111	----	122	111	----	----
8	140+0+0	Spring only	103	----	106	104	99	94	91	106	----	96	104	119	115
LSD @5% level				15	12	10	13	11	13	12	20	11	16	11	12
CV(%)				9	9	8	10	8	9	9	16	8			

Experimental Design:RCB with 4 reps

Variety all years=Arctic Green

Yield Trial mean by year (#/acre)-- 1525 1276 1584 1668 1631 1627 1220 1344 1244 1068 1499 1313

<sup>1</sup>Split-30-40-40 applied fall and remainder in spring(increased to 30-50-50 in 2019)<sup>2</sup>Split-30-50-50-20s(77#AMS / acre) applied in fall+110-0-0 in early May<sup>3</sup>Treatment overall means should be viewed with caution when there are limited number of years-(ie-#6-7)

### Trt. # Explanation of fertility treatments

- 1 No fertilizer added
- 2 30-40-40 applied Sept-Oct. / 70-0-0 applied early May
- 3 30-40-40 applied Sept.-Oct. / 110-0-0 applied early May (standard)
- 4 30-40-40 applied Sept-Oct. / 110-40-0 applied early May
- 5 30-40-40-20s(77#AMS) Sept-Oct
- 6 30-40-40 applied Sept-Oct. / 90-0-0 applied May / 7 gal. 28%UAN applied mid-June
- 7 30-40-40 applied Sept-Oct./ 150-0-0 applied early May
- 8 30-40-40 applied Sept.-Oct. / 110-0-0-20s applied early May

Table 11.

**2022 Fertilizer Added Late to Per. Ryegrass That Has Been Flooded**  
**Rice Farm-Roseau,Mn** Variety=Patriot 4

Trt#	Added <sup>1</sup> Fertilizer	Fertilizer Source	Yield <sup>2</sup>		RCI <sup>3</sup> 8/10	Harvest Ht.(in.)
			#/acre	Estimated		
1	40-0-0	Urea-46-0-0	609	800	486	22
2	0-40-40	0-46-0 + 0-0-60	667	775	396	20
3	40-0-0 <sup>1</sup>	13GPA-28%N	634	800	399	21
4	None	0	634	800	383	20
LSD @5% level			NS	NS	89	NS
CV(%)			10	10	13	9

Experimental Design: RCB w/4 reps

Variety= Patriot II

<sup>1</sup>Treatr Liquid 28% N sprayed on with flat fan nozzels @ 13GPA

<sup>2</sup>Yield= Actual harvested yield and visual estimate prior to harvest

<sup>3</sup>Relative Chlorophyll Index- higher number=more chlorophyll

Harvest date=8/11/2022

All Fertilizer applied- 6/10/2022

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Table 12.

**2022 Growth Regulator Applications to Per. Ryegrass**  
**Rice Farms-Northwest of Roseau,Mn**

Trt#	PGR treat	additive	Seed Yield #/acre	Harvest Ht(in.)	Lodging <sup>4</sup>		
					14-Jul	21-Jul	Harvest
1	No treatment		883	29	6.3	7.3	7.8
2	Apogee 6oz.	.25%NIS+4.5gal.UAN	1081	25	1.8	3.3	3.8
3*	Apogee 6oz.	.25%NIS+6gal.AmSol	943	26	2.3	4.3	4.5
4	Apogee 6oz.	.25%NIS+6gal.UAN	932	24	1.5	4.0	4.0
5	Apogee 6oz.	.25%NIS+3gal.UAN	1021	25	1.3	3.8	3.8
6	Apogee 8oz.	.25%NIS+3gal UAN	979	23	1.5	3.0	3.0
7	Apogee 8oz.	.25%NIS+2.5% UAN	1057	24	2.0	2.8	3.0
8	Apogee 8oz.	.25%NIS+3gal.AMS	932	24	3.0	3.5	3.3
LSD @5% level			124	2	1.3	1.3	1.6
CV(%)			8	5	38	24	26

Experimental design=RCB w/4reps

Variety= Patriot II

Harvest date=8/4/2022

1.7Pt Wolverine+8oz.AmSol+ 2oz. Warrior applied 6-23-2022 to all plots

\*Trt#3 had some product precipitated out with the high AmSol

1 gallon AmSol = 3.4# AMS(6gallons= 20#AMS/acre)

1gal=3.4#ams(21-0-0-24s) .7#N-0-0-.8#s

1gal 28%UAN=3#N

Applications made6-22-2022. Canopy= 23-26" and 3-4 nodes

78F 37%RH SW4-10mph 6-22-2022 7PM

Applications may have been later than ideal.

Table 13.

**2022 Pre-emergent Herbicides applied to Ryegrass****Rice Farm- Roseau,Mn**

48 52.627'N . 95 52.000'W

TRT#	Trade Name	common name	Product Rate/acre	Seed Yield <sup>1</sup>		Stand <sup>2</sup>		Injury <sup>3</sup>	Harvest	
				#/acre	Estimated	2-Jun	14-Jul	11-Jun	Date	Ht(in.)
1	Zidua SC	pyrooxasulfon	2oz.	<b>1066</b>	1000	63	68	6.0	10-Aug	23
2	Callisto	Mesotrione	6oz.	<b>1095</b>	1350	100	93	1.8	5-Aug	23
3	Boundary	metribuzin+metalachlor	1.5pt	<b>832</b>	925	73	58	5.5	10-Aug	23
4	Aatrex	atrazine 4L	1pt	<b>779</b>	950	75	73	3.8	8-Aug	22
5	Aatrex	atrazine 4L	2pt	<b>458</b>	650	63	35	6.8	11-Aug	20
6	GoalTender+Nortron	oxyfluorfen+ethofumisate	2oz+2pt	<b>1072</b>	1400	100	100	2.0	5-Aug	23
7	Dual II Magnum	metalachlor	1pt	<b>1059</b>	1275	85	85	2.8	7-Aug	24
8	Avadex	trallate	15#	<b>1003</b>	1050	63	68	4.5	10-Aug	23
9	Anthem Flex	Carfentrazone-ethyl + pyrooxasulfone	3oz	<b>814</b>	875	40	50	6.8	11-Aug	23
10	Anthem Flex	Carfentrazone-ethyl + pyrooxasulfone	4oz	<b>602</b>	825	40	50	7.5	11-Aug	20
11	No treat			<b>1099</b>	1300	100	98	1.0	5-Aug	23
12	No treat-Harrow			<b>1161</b>	1325	100	100	1.0	6-Aug	24
13	Avadex-Harrow	trallate	15#	<b>1061</b>	1025	73	88	4.8	8-Aug	23
LSD @5% level				<b>168</b>	191	20	17	1.1	2	2
CV(%)				12	12	18	16	19	16	6

Experimental Design: RCB w/4 reps

Variety=Patriot 4

All treatments(except Avadex) applied 11am 5/6/2022. wind SE 9-14 64F 52%RH

GS-ryegrass just beginning to greenup--wheat stubble 7" high.

Application made w/ 10' bike sprayer 8002 T-Jet nozzels @26PSI and 12GPA

Avadex applied 7pm 5/6

Rainfall after application 5/8=0.43", 5/9=1.24", 5/11 =0.5"

Trts. 12-13 spike tooth harrowed 5/7 8am

Soil type=Borup silt loam

Anthem Flex Carfentrazone-ethyl .3# + Pyrooxasulfone 3.7#

Aatrex 4# atrazine

Avadex 10%trallate

Goal Tender 4# oxyfluorfen

Dual II Magnum 7.6# metalachlor

Zidua SC pyrooxasulfon 4.17#/gal

Nortron 4# ethofumisate

Callisto 4# Mesotrione

Boundary 5.25#metalachlor+ 1.25# metrabuzin

<sup>1</sup>Seed Yield- actual harvested clean seed and visual estimate<sup>2</sup>Stand- visual %stand<sup>3</sup>injury/suppression-visual rating- 1=no injury 9=severe injury

Table 14.

**2022 Perennial Ryegrass Management Additive Trial  
Magnusson Research Farm**

Trt#	Herbicide Treatment <sup>1</sup>	Rate	Manage Level <sup>2</sup>	Seed Yield(#/acre)				% stand	Ht(in.)
				2022	2021	2020	3yr.ave		
1	Callisto+Sterling Blue+2,4-D/Assurell	3oz+12oz+12oz/12oz	BMP	<b>1324</b>	1297	1370	1330	86	21
2	Callisto+Sterling Blue+2,4-D/Assurell	3oz+12oz+12oz/12oz	BMP	<b>1340</b>	1388	1546	1425	86	22
3	Callisto+Sterling Blue+2,4-D/Assurell	6oz+12oz+12oz/12oz	BMP	<b>1430</b>	1206	NA <sup>3</sup>	1318	86	23
4	Sterling Blue+2,4-D/Assurell	12oz+12oz/12oz	BMP -	<b>1408</b>	1235	1506	1383	85	23
5	Sterling Blue+2,4-D/Assurell	12oz+12oz/12oz	BMP	<b>1428</b>	1374	1412	1405	90	22
6	Sterling Blue+2,4-D/Assurell	12oz+12oz/12oz	BMP +	<b>1422</b>	1224	1541	1397	90	23
7	Sterling Blue+2,4-D/Assurell	12oz+12oz/12oz	BMP ++	<b>NH*</b>	1197	1356	----	----	----
8	Wolverine Advance	1.7pt +1pt.	BMP	<b>1442</b>	1304	1359	1368	86	21
9	Facet+2,4-D+Sterling Blue	1.5pt+12oz+12oz	BMP	<b>NH*</b>	1257	1362	----	----	----
10	Sterling Blue+2,4-D+Dual II/Tacoma	12oz+12oz+1pt/12oz	BMP	<b>NH*</b>	1311	1394	----	----	----
11	No Treatment		BMP	<b>1430</b>	1108	1263	1267	86	23
LSD @ 5% Level				<b>168</b>	148	138	146	NS	NS
CV(%)				<b>8</b>	8	5	5	6	7
Experimental design:RCB with 4 reps			Mean Yield-	1403	1264	1411			

<sup>1</sup>Herbicide treatment- stand issues in certain areas of the field precluded getting at least 3 replications of some treatments. These treatments had stand not sufficient for comparison (trts.7,9 & 10).  
Harvest date=8/6/2022

Variety=Arctic Green-- 3/4pt 2.4-D+3/4pt.Banvel applied 9-20-2021 to all plots

<sup>2</sup>Management level- higher or lower than best management practice on treatments other than herbicide

<sup>3</sup>6 oz. Callisto treatment 2021-22 only

6/4 broadleaf herbicide 9am 57F wind N3 GS 2-5" tillering  
6/10 grass herbicide= 10am 64F  
6-17 Apogee 11:30am 69F wind 3NE GS tillering-10%headed  
6-27 Fungicide = 9:30am wsw 2-6mph 70F  
early pollen shedding

BMP = (Best management practice) 6oz. Apogee+2 Gal. 28%N +low cost fungicide / premium fungicide + 1gal 28%N 3 weeks before harvest

BMP - = BMP substitute no fungicide with Apogee / substitute low cost fungicide only 3 weeks before harvest

BMP + =growth regulator + premium fungicide + insecticide1X

BMP ++ =growth regulator + premium fungicide + insecticide 2X

**Trt# 2021 Treatment and Date**

1--	3oz.Callisto+2,4-D+Banvel 6-4 /Assurell 6-10/ Apogee + Tilt+ 2 gal 28%N 6-17 / Priaxor +1 gal 28%N 6-27
2--	3oz Callisto+ 2,4-D+ Banvel 6-4 +MSO+28%N 6-4/ Assurell 6-10/ Apogee + Tilt+ 2 gal 28%N 6-17 / Priaxor +1 gal 28%N 6-27
3--	6 oz Callisto+ 2,4-D+ Banvel 6-4/ Tacoma 6-2/ Apogee + Tilt+ 2 gal 28%N 6-17 / Priaxor +1 gal 28%N 6-27
4--	2,4-D+ Banvel 6-4/ Assurell 6-10/ Apogee + 2gal 28%N 6-17 / Folicur 6-27
5--	<b>2,4-D+ Banvel 6-4/ Assurell 6-10/ Apogee + Tilt+ 2gal 28%N 6-17 / Priaxor 6-25+1gal 28%N 6-27(standard BMP)</b>
6--	2,4-D+ Banvel 6-4/ Assurell + 2gal 28%N +Folicur 6-10/ Apogee + Quilt+ Warrior+2gal 28%N 6-17 / Priaxor +1gal 28%N 6-27
7--	2,4-D+ Banvel 6-4/ Tacoma + 2gal 28%N +Folicur 6-10/ Apogee + Quilt+ Warrior +2gal 28%N 6-17 / Priaxor +Warrior+1gal 28%N 6-27
8--	2,4-D+ Banvel 6-4/ Tacoma +2 gal 28%N +Folicur 6-10/ Apogee + Quilt +2gal 28%N 6-17 / Priaxor-1gal 28%N 6-27
9--	Wolverine 6-10/ Apogee + Tilt + 2gal 28%N 6-17 / Priaxor + 1gal 28%N 6-27
10--	2,4-D+ Banvel+Dual II Magnum 6-4/ Tacoma 6-10/ Apogee + Tilt+ 2 gal 28%N 6-17 / Priaxor +1 gal 28%N 6-27
11--	NO HERBICIDE--Apogee + Tilt+ 2 gal 28%N 6-17 / Priaxor +1 gal 28%N 6-27

Trade Name	Common name -Active ingredient/gallon(or % dry)	Use Rate/acre
Quelex	10% halauxifen+10% florasulum	.75oz
WideMatch	.75#CLOPYRALID + .75#FLUROXYPYR	1pt
Assure II	.88# Quizalofop	12oz
Callisto	4# mesotrione	3oz
Sterling Blue	4# Dicamba	.75pt
2,4-D	4# 2,4-D amine	.75pt
Wolverine Advance	.4#Fenoxaprop +13#pyrasulfotole+1.05#bromoxynil	1.7pt
Apogee	27.5% PROHEXADIONE CALCIUM	8oz
Preference	Non-ionic surfactant(90%NIS) (.25%NIS)	1qt./100gallons water
Amsol	1gallon=3.4# dry AMS =.7#N/gal	1 pt
28%N	2.9#N(UAN)/Gal	3 gal
MSO-Destiny	92%MSO	1 gallon/100gallons
Tilt	3.6#Propiconazole	4 oz
Quilt Xcel	1.02#PROPICONAZOLE + 1.18#AZOXYSTROBIN	12oz
Priaxor	1.39#FLUXAPYROXAD +2.78# PYRACLOSTROBIN	6oz
Warrior(Grizzly)	2.08#LAMBDAHALOTHHRIN	1.5oz
Folicur	3.6#Tebuconazole	4oz

Table 15.

**2022 Ryegrass Fungicide Trial-  
Rice Farms-Northwest of Roseau,Mn**

Trt#	Product	Rate/acre	Seed Yield Harvest	
			#/acre	Ht(in.)
1	Quilt Xcel	12oz+.25%NIS	1010	24
2	Folicur	5oz+.25%NIS	941	24
3	Priaxor	6oz+.25%NIS	952	23
4	Quilt Xcel	12oz+.25%NIS+3gal.Amsol	990	24
5	Quilt Xcel	12oz+.25%NIS+3gal. 28%N	990	23
6	Revytek	8oz+.25%NIS	1032	23
7	No treatment		952	23
LSD @5% level			NS	NS
CV(%)			10	6

Experimental design=RCB w/4reps

Variety=Patriot 4

Harvest date=8-2-2022

Nexicor fluxapyroxad .25#,pyroclostrobin 1.67#,propiconazole 1.04#

Priaxor fluxapyroxad 1.39#,pyroclostrobin 2.78#

Folicur 3.6F tebuconazole 3.6#

Quilt Xcel Azoxystrobin 1.18#, propiconazole 1.02#

Grizzly Z II Lambda-cyhalothrin 2.08#

Warrior w Lambda-cyhalothrin 2.08#

Revytek (menfentrifluconazole + pyraclostrobin + xemium) = BAS 753

Lamcap II Lambda-cyhalothrin 2.08#

Applications made 7/6/2022. 5:30PM. 78F 57%RH,wind S 11mph Pcldy.  
GS=22-25" ht.

Table 16.

**2021-22 Callisto-Nortron on P Ryegrass  
Magnusson Research Farm-Roseau,Mn**

Trt#	Early fall	Fall/spring	Date	Yield #/acre	Harvest Ht.(in.)
1	Callisto	Callisto	6-May	1357	19
2	Nortron	Callisto	6-May	1317	21
3	0	Callisto	6-May	1268	24
4	Callisto	Callisto	25-Oct	1206	20
5	Nortron	Callisto	25-Oct	1393	23
6	0	Callisto	25-Oct	1473	20
7	Callisto	No treatment	0	1402	22
8	Nortron	No treatment	0	1410	23
9	0	No treatment	0	1264	22
10	Callisto	Nortron	6-May	1615	20
11	Nortron	Nortron	6-May	1549	20
12	0	Nortron	6-May	1486	20
13	Callisto	Nortron	25-Oct	1161	20
14	Nortron	Nortron	25-Oct	1375	20
15	0	Nortron	25-Oct	1357	18
LSD @ 5% Level				NS	3
CV(%)				16	6

Experimental Design:RCB w/4reps(only 2 reps harvested)

Harvest date 8/10/2022

**Early Fall (9-9-2021) Rates & adjuvants** applied 9/9/2021 12:30pm 66F wind 2-5 ssw

Callisto 3oz+1%CO<sub>2</sub>+2.5%UAN ryegrass 2-3" overcast

Nortron 2pts wheat 2-3" 1-2leaf RH62%

**Fall/Spring(10/25&5/6)Rates**

Callisto 6oz. Applied 5/6/22 6pm mostly sunny

Nortron 2pts wind ssw10 65F

Ryegrass just greening up

Trade

Name	Common name
Callisto	Mesotrione 4#/gal.
Nortron SC	Ethofumisate 4#/gal



Table 19.

**2021-22 Wheat Stubble Management for Production of P Ryegrass  
Magnusson Research Farm-Roseau.Mn**

Trt#	Product	Rate/acre	Seed Yield		%Stand		Vigor <sup>1</sup>	Harvest Ht(in.)
			#/acre	Estimated	6-May	14-Jun		
1	no treatment		1386	1275	80	80	7.8	21
2	spring clip 3"		1415	1325	75	78	7.0	21
3	spring clip 3"- bale off		1353	1375	70	73	7.3	21
4	Fall clip 3"- bale off		1377	1025	30	40	3.8	22
5	Fall clip 5"-10-11-21		1435	1250	65	73	7.0	21
	LSD @5% level	NS	172	17	14	1.5	2	
	CV(%)	12	9	17	14	15	6	

Experimental Design:RCB w/4reps

<sup>1</sup>Vigor-1=poor;9=good

Spring clip 5/6/2022

Fall clip 10/11/2021

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Table 19a.

**Spring Residue Management Seed Yield Summaries-2018-2022  
Rice Farms 2018 and 2021  
Magnusson Research Farm-2019-22**

Trt#	Clip Treatment <sup>1</sup>	Seed Yield-#/acre					Mean
		2022	2021	2020	2019	2018- <sup>2</sup>	
1	No Treatment	1386	1172	1395	1386	1430	1353
2	Clip only	1415	1222	1475	1497	NA	1402
3	Clip-Rake off	1353	1380	1537	1611	1610	1498
	LSD @ 5% Level	NS	118	NS	197	63	
	CV(%)	12	5	8	7	2	

Experimental Design:RCB w/4reps

Fall wheat stubble combine height=6"-8"

Varieties= Rice farm- 'Evolution'

Magnusson Research farm-'Arctic Green'

<sup>1</sup>-Clip only or clip and remove straw late April-early May

Clip height=3"

<sup>2</sup>-No clip treatment in 2018 from Rice Farms location.

Plot size about 10' x 30'. Stubble cut with sickle mower or lawn mower

Residue on Trt#3 raked off by hand.



Table 20.

**%Endophyte on Seed Produced in 2022<sup>a</sup>**

Cultivars	Production	
	Area	Endophyte
Furlong	Badger	80%
Galactic Green	Wannaska	0%
Defender	Roseau	0%
Interlude	Roseau	30%
Coda	Roseau	5%
Peridot	Roseau	20%
Reservoir	Roseau	0%
Hancock	Roosevelt	20%
Fiesta IV	Roseau	50%
Galactic Green	Roseau	0%
Karma	Roseau	5%
SR4700	Roosevelt	65%
Allaire III	Pine creek	50%
Patriot IV	Roseau	5%
Fiesta Cinco + Sideways	Grygla	80%
Silver Dollar	Grygla	5%
Spark	Grygla	60%
Sideways	Roseau	15%
Gator III	Roseau	0%

*Epichloë* endophytes are fungi growing inside grass leaf sheaths and leaves.

*This fungus can protect the plant from insect damage by producing certain alkaloid compounds.*

*These alkaloids include lolines, lolitrems, ergovaline and peramine.*

*Strains of Epichloë endophytes can produce none of those up to all of them.*

*The presence of endophyte in grass tissue does not indicate with certainty that all these alkaloids will be produced;*

*Furthermore, accumulation of these alkaloids can be different between the plant's organs (roots, stem, leaf sheath, leaves, panicles and seeds).*

Two of these alkaloids have negative impact on animal health.

Ergovaline is associated with "fescue toxicosis" (from tall fescue) and can affect many grazing animals such as cattle, sheep, goats, horses, and even deer.

Lolitrems B provokes "ryegrass staggers" (from perennial ryegrass) by impacting cattle, sheep and horse muscular coordination.

We tested the presence of endophyte in freshly harvested (summer 2022), threshed and clean seeds from various growers in different Northern Minnesota areas.

We observed that 5 of the 19 seed-lot tested were free of endophyte; the remaining seed-lots contained endophyte with percentage ranging from 5% to 80%.

The test allowed us to determine the endophyte presence and incidence but we do not know the alkaloid profiles present the colonized perennial ryegrass cultivars.

Galactic green cultivar did not possess any endophyte in two different seed-lots tested.

The residue from this perennial ryegrass cultivar could be ideal in cattle feeding after seed harvest.

However, the absence of the endophyte indicates that no protection from insect damage will occur and growing fields will have to be monitored closely for any above ground feeding insect infestation.

<sup>a</sup> Text and summary table courtesy of Dr. Florence Sessoms-University of Minnesota.

Table 21 .

**2020-21 Kernza Residue Management  
Magnusson Research Farm. 2022 Data and 2021-22 Yields.**

TRT#	Treatment	Seed yield #/acre			Harvest Ht(in.)	% Heading			
		2021	2022	mean		22-Jun	26-Jun	1-Jul	5-Jul
1	Burn	594	773	683	60	18	63	91	99
2	Bale at harvest	433	509	471	54	10	48	81	94
3	Bale-Short clip+Bale	392	418	405	49	8	40	68	86
4	No Treatment	264	499	382	56	1	28	65	90
LSD @ 5% Level		201	122	139	5	6	13	12	5
CV(%)		30	13	18	6	47	18	10	3

TRT#	Treatment	Dry Matter(T/acre)		Protein <sup>1</sup>		RCI <sup>3</sup>	
		2021	2022	%DM	%TDN <sup>2</sup>	3-Jun	17-Jun
1	Burn	2.5	5.4	4.9	68.0	395	385
2	Bale at harvest	2.1	3.8	5.0	68.3	340	302
3	Bale-Short clip+Bale	1.8	3.3	4.5	68.3	307	317
4	No Treatment	1.4	4.2	6.8	67.7	306	418
LSD @ 5% Level		0.7	1.5	1.1	0.6	NS	76
CV(%)		25	23	13	1	18	13

Experimental Design:RCB/w 4 reps

Harvest Date= 8-9-2021 , 8/22/2022

Kernza variety=MN-Clearwater

Harvested 8/5/2020

Trt#1 Burned 8-11-2020, 8/25/2021

Trt#2 Raked off 8-10-2020, 8/11/2021

Trt#3 Clip-Rake 9-9-2020,9/27/2021 Flail chopped off to 4" ht.

Trt#4 Kernza harvested and residue left on plot

<sup>1</sup> %Protein on Dry Matter basis

<sup>2</sup> Total digestible nutrients of the dry matter.

<sup>3</sup> RCI- Higher number = more relative level of chlorophyll.

Table 22.

**2020 & 2021 Hard Fescue Fertility Management**

2022 Magnusson Research Farm- Roseau, Mn

2022 Data + 2021 Seed Yield

Added Fertilizer	Seed Yield(#/acre)			Dry Matter tons/ac	% Heading			RCI <sup>1</sup>		Harvest	
	2021	2022	Ave.		31-May	4-Jun	8-Jun	3-Jun	18-Jun	Lodge <sup>2</sup>	Ht(in.)
0-40-40	378	730	554	1.32	23	70	95	194	232	1.0	21
40-40-40	670	980	825	1.85	28	53	91	296	298	1.0	26
80-40-40	903	1305	1104	2.28	20	50	89	383	335	1.8	27
120-40-40	854	1486	1170	2.73	15	48	88	437	338	2.0	27
160-40-40	1001	1464	1233	2.68	15	48	86	488	356	2.8	27
LSD @ 5% Level	161	163	125	0.41	8	9	6	18	42	0.8	2
CV(%)	13	9	8	12	25	10	4	3	9	32	4

Experimental Design-RCB w 4 reps

Variety=MN-HD

Harvest Date-7-7-2022 & 6-25-2021

Fertilizer applications -September 27,2021 and Sept 25,2020

<sup>1</sup>Relative Chlorophyll Index- higher number=more chlorophyll

<sup>2</sup>Lodging-1=upright ; 9=flat

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Table 23.

**2020 & 2021 Hard Fescue Residue Management**

Magnusson Farm-1 Mile SW of Roseau, Mn

2022 data + 2021 Seed Yield

	Seed Yield(#/acre)			Yield Estimate	Dry Matter Tons/ac	Test Weight	Germ <sup>1</sup>	Harvest Ht(in.)	%heading			RCI <sup>2</sup>	
	2022	2021	Mean						31-May	4-Jun	8-Jun	3-Jun	18-Jun
1-Desiccate-Burn	596	601	599	575	0.91	19.9	81%	24	19	38	75	510	599
2-Bale after harvest	580	567	574	563	0.91	19.7	89%	24	3	10	60	386	603
3-Bale-Cut/Bale late	438	514	476	475	0.66	16.9	80%	23	5	13	60	463	662
4-No treatment	400	418	409	475	0.69	16.6	68%	24	T	6	53	302	626
LSD @ 5% Level	168	138	135	125	0.19	2.1	NA	NS	9	11	17	67	135
CV(%)	20	16	13	15	14	12	NA	5	81	43	17	10	13

Experimental Design-RCB w 4 reps

Harvested 6-25-2021 & 7/7/2022

<sup>1</sup>Germination- Seed germination of cleaned seed by treatment.

Variety=MN-HD

<sup>2</sup>RCI- Relative chlorophyll index-Higher number =more chlorophyll

Trt#2-3- baled off after harvest 7-9-2020 & 8/3/2021

Trt#3- clipped/raked off 9-15-2020 & 9/15/2021

Trt#1-Gramoxone Max applied 7/30/2020 4pm 81F 42%RH wind s and burned 8-6-2020

Trt#1-Gramoxone Max applied 7/27/2021 3pm 74F 52%RH wind 3-5 ESE mostly sunny burned 8/30/2021

Gramoxone Rate= 1.5pt.+ .25%NIS

Burned 8-30-2021(late because of burn restrictions-drought)

Table 24.

**2021-22 Estimated Straw Value and Cost to Replace Removed Nutrients  
After Seed Harvest On 4 Grass Species and Rye**

<b>Crop</b>	<b>Yield Tons/ac.<sup>1</sup></b>	<b>\$\$ Straw Value</b>		<b>Nutrient Removal/Replacement Cost<sup>2</sup></b>				
		<b>\$\$/Ton Residue</b>	<b>Total\$\$/acre Residue</b>	<b>\$\$/Ton Nitrogen</b>	<b>\$\$/Ton Phosphorous</b>	<b>\$\$/Ton Potash</b>	<b>\$\$/ton N+P+K</b>	<b>\$\$/acre N+P+K</b>
<b>Kernza Average-</b>	<b>4.3</b>	<b>\$107.00</b>	<b>\$459.00</b>	\$11.52	\$4.00	\$22.03	<b>\$37.55</b>	\$161.47
<b>Per. ryegrass Average-</b>	<b>2.4</b>	<b>\$114.00</b>	<b>\$272.50</b>	\$15.73	\$5.29	\$28.51	<b>\$49.54</b>	\$118.90
<b>Ky.bluegrass Average-</b>	<b>2.1</b>	<b>\$122.00</b>	<b>\$256.00</b>	\$14.33	\$5.29	\$25.92	<b>\$45.54</b>	\$95.63
<b>Hard Fescue Average-</b>	<b>1.1</b>	<b>\$130.00</b>	<b>\$143.00</b>	\$21.22	\$5.94	\$28.94	<b>\$56.11</b>	\$61.72
<b>Rye Average-</b>	<b>1.2</b>	<b>\$60.00</b>	<b>\$80.00</b>	\$10.58	\$4.97	\$11.63	<b>\$27.18</b>	\$32.62

N (Urea) 46-0-0 =**\$ .70/#**

P2O5(MAP) 11-52-0= **\$ .57/#** (includes-\$.15/# due to N credit)

K2O(Potash) 0-0-60=**\$ .53/#**

<sup>1</sup>Yield tons/acre- dry matter per acre

<sup>2</sup>Cost of nutrient replacement when residue is removed.

Table 24a.

**2020 Estimated Straw Value and Cost to Replace Removed Nutrients  
After Seed Harvest On 4 Grass Species by Treatment or Location**

Field <sup>1</sup>	Harvest year	Location/trial	Prior year <sup>2</sup>		Yield <sup>3</sup> Tons/ac.	\$\$ Value		Nutrient Removal/Replacement Cost <sup>4</sup>					Forage Quality of Removed Residue <sup>5</sup>						
			residue management	Planting Date		Variety	\$\$ Value/ Ton	Total/acre Residue	\$\$ N/Ton	\$\$ P/Ton	\$\$ K/Ton	\$\$ N P K / ton	\$\$ N P K / acre	%Crude Protein	% Ash	Cal/#	Cal/#	% Acid detergent fiber(ADF)	% Total Digestible nutrients
<b>Kernza</b>																			
S	2021	Research farm	1-Burn	9/19	Mn-Clearwater	2.5	\$107	\$268	\$11.52	\$4.00	\$22.03	\$37.55	\$93.88	4.9	4.0	0.7	1.4	43.0	68.0
S	2021	Research farm	2-Bale	9/19	Mn-Clearwater	2.1	\$107	\$225	\$11.52	\$4.00	\$22.03	\$37.55	\$78.86	5.0	4.1	0.7	1.4	41.7	68.3
S	2021	Research farm	3-Bale+clip	9/19	Mn-Clearwater	1.8	\$107	\$193	\$11.52	\$4.00	\$22.03	\$37.55	\$67.59	4.5	3.9	0.7	1.4	42.7	68.3
S	2021	Research farm	4-None	9/19	Mn-Clearwater	1.4	\$107	\$150	\$11.52	\$4.00	\$22.03	\$37.55	\$52.57	6.8	5.0	0.7	1.4	39.3	67.6
S	2022	Research farm	1-Burn	9/19	Mn-Clearwater	5.4	\$107	\$578	\$11.52	\$4.00	\$22.03	\$37.55	\$202.77	4.0	5.3	0.7	1.3	47.0	66.5
S	2022	Research farm	2-Bale	9/19	Mn-Clearwater	3.8	\$107	\$407	\$11.52	\$4.00	\$22.03	\$37.55	\$142.69	3.9	4.9	0.7	1.3	46.5	66.8
S	2022	Research farm	3-Bale+clip	9/19	Mn-Clearwater	3.3	\$107	\$353	\$11.52	\$4.00	\$22.03	\$37.55	\$123.92	4.3	5.4	0.7	1.3	45.9	66.6
S	2022	Research farm	4-None	9/19	Mn-Clearwater	4.2	\$107	\$449	\$11.52	\$4.00	\$22.03	\$37.55	\$157.71	4.6	5.7	0.7	1.3	45.2	66.3
F	2022	Estling farm	Burn	9/19	Mn-Clearwater	5.5	\$107	\$589	\$11.52	\$4.00	\$22.03	\$37.55	\$206.53	8.6	5.8	0.7	1.3	43.6	65.7
Kernza Average-						3.33		\$357					\$77.18	5.2	4.9	0.7	1.3	43.9	67.1
<b>Ryegrass</b>																			
F	2022	Rice Farms		5/2021	Patriot 4	2.3	\$114	\$262	\$15.73	\$5.29	\$28.51	\$49.54	\$113.94	12.6	7.8	0.7	1.3	40.7	63.7
F	2022	Rice Farms		5/2021	Allaire 3	2.7	\$114	\$308	\$15.73	\$5.29	\$28.51	\$49.54	\$133.76	5.1	7.1	0.7	1.3	40.8	65.7
F	2022	Magnusson farms		9/2021	Galactic green	2.0	\$114	\$228	\$15.73	\$5.29	\$28.51	\$49.54	\$99.08	12.8	7.8	0.7	1.3	38.8	63.9
F	2022	Brateng farm		9/2021	Sideways	2.0	\$114	\$228	\$15.73	\$5.29	\$28.51	\$49.54	\$99.08	10.6	7.4	0.7	1.3	42.2	64.2
F	2022	Stanley farm		5/2021	Silver dollar	2.4	\$114	\$274	\$15.73	\$5.29	\$28.51	\$49.54	\$118.90	8.5	10.4	0.6	1.2	40.4	62.6
F	2022	Estling farm		5/2021	Galactic green	2.6	\$114	\$296	\$15.73	\$5.29	\$28.51	\$49.54	\$128.80	9.1	8.1	0.7	1.3	37.7	64.7
Perennial ryegrass Average-						2.33		\$266					\$115.59	10.6	8.9	0.8	1.5	47.4	75.3
<b>Kentucky.bluegrass</b>																			
F	2021	Research farm	Burn	8/2019	Park	1.7	\$122	\$207	\$14.33	\$5.29	\$25.92	\$45.54	\$77.00	9.8	6.1	0.7	1.3	39.0	65.8
F	2022	Research farm	Burn	8/2019	Park	2.0	\$122	\$244	\$14.33	\$5.29	\$25.92	\$45.54	\$91.00	9.1	7.5	0.7	1.3	41.5	64.5
F	2022	Douglas Erickson	Burn	8/2019	Park	3.1	\$122	\$378	\$14.33	\$5.29	\$25.92	\$45.54	\$141.00	7.2	6.6	0.7	1.3	38.1	66.0
F	2022	Wensloff farm	Burn	8/2020	Park	2.0	\$122	\$244	\$14.33	\$5.29	\$25.92	\$45.54	\$91.00	7.9	6.8	0.7	1.3	42.1	65.1
F	2022	Habstritt farm	Burn	8/2019	Park	2.5	\$122	\$305	\$14.33	\$5.29	\$25.92	\$45.54	\$114.00	9.7	5.6	0.7	1.3	39.3	66.2
F	2022	Estling farm	Burn	8/21	Dragon	2.0	\$122	\$244	\$14.33	\$5.29	\$25.92	\$45.54	\$91.00	7.5	6.7	0.7	1.3	44.2	64.9
Kentucky.bluegrass Average-						2.22		\$270					\$100.83	8.5	6.6	0.7	1.3	40.7	65.4
<b>Hard Fescue</b>																			
F	2021	Magnusson farms	None	8/2019	MN-HD	1.30	\$130	\$169	\$21.22	\$5.94	\$28.94	\$56.11	\$73.00	4.4	4.6	0.7	1.3	45.8	67.0
S	2022	Magnusson farms	1-Burn	8/2019	MN-HD	0.91	\$130	\$118	\$21.22	\$5.94	\$28.94	\$56.11	\$51.00	4.9	4.2	0.7	1.3	46.3	67.2
S	2022	Magnusson farms	2-Rake off	8/2019	MN-HD	0.91	\$130	\$118	\$21.22	\$5.94	\$28.94	\$56.11	\$51.00	6.6	4.3	0.7	1.3	43.8	67.1
S	2022	Magnusson farms	3-Rake-clip	8/2019	MN-HD	0.66	\$130	\$86	\$21.22	\$5.94	\$28.94	\$56.11	\$37.00	6.0	4.4	0.7	1.3	43.6	67.2
S	2022	Magnusson farms	4-None	8/2019	MN-HD	0.69	\$130	\$90	\$21.22	\$5.94	\$28.94	\$56.11	\$39.00	6.6	4.2	0.7	1.3	42.7	67.4
Hard Fescue Average-						0.89		116.20					50.20	5.70	4.34	0.70	1.30	44.44	67.18
<b>Rye</b>																			
F	2021	Magnusson farms		9/2020	Serafino	1.3	\$60	\$75	\$10.58	\$4.97	\$11.63	\$27.18	\$34.00	4.2	6.6	0.7	1.3	50.5	64.9
F	2021	Magnusson farms		9/2020	Bono	1.2	\$60	\$69	\$10.58	\$4.97	\$11.63	\$27.18	\$31.00	6.8	5.2	0.7	1.3	46.6	66.2
Spring wheat Average-						1.25		\$72					\$33	5.5	5.9	0.7	1.3	48.6	65.6

Experimental Design: 2-4 samples taken per treatment- no statistical analysis

N (Urea) 46-0-0 = \$.70/#

P2O5(MAP) 11-52-0= \$.57/# (includes \$.15/# due to N credit)

K2O(Potash) 0-0-60= \$.53/#

<sup>1</sup>Field-S=small plot treatment;F=production field sampling

<sup>2</sup>Residue treatment-

1-Paraquat + fall burn

2-Rake off only after harvest

3-Rake off after harvest + clip 3" rake off 4 weeks later

4-No treatment-leave residue in place

<sup>3</sup>Yield tons/acre- on dry matter per acre basis

<sup>4</sup>Cost of nutrient replacement from baled residue

<sup>5</sup>Forage quality of main dry matter components of residue



Table 27.

**2022 Cover Crop Evaluation**  
**Magnusson Research Farm-Roseau,Mn**

						Top Growth			Root Growth			
<b>Wheat stubble-F4</b>						Fresh wt.	Dry wt.	%dry	Fresh wt.	Dry wt.	%dry	
Treat#	Species	Variety	Stand <sup>1</sup>	Vigor <sup>2</sup>	%GC <sup>3</sup>	Ht(in.)	#/acre	#/acre	#/acre	#/acre	#/acre	#/acre
						10/7	10/10	10/10	10/10	10/10	10/10	10/10
1	Canola	L340PC	6.3	7.7	35	3	6428	748	12	NA	NA	NA
2	Radish	Tapmaster Daikon	5.7	6.3	20	3	2878	365	13	193	27	14
3	Rape	Barsica forage	6.3	6.3	40	3	3358	422	13	NA	NA	NA
4	Turnip	Barkant	7.0	7.7	53	5	8731	988	12	414	58	14
5	Pea	4010 forage field pea	3.0	5.7	10	3	6716	1238	19	NA	NA	NA
6	Crimson clover	VNS	8.3	8.3	22	1	NA	NA	NA	NA	NA	NA
7	Red clover	Ruby	7.0	6.3	22	1	NA	NA	NA	NA	NA	NA
8	Hairy vetch	190VNS	3.7	5.0	25	3	NA	NA	NA	NA	NA	NA
9	Buckwheat*	VNS	8.3	6.3	10	2	384	115	31	NA	NA	NA
10	Flax	Omega	9.0	9.0	40	4	1343	192	15	NA	NA	NA
11	Triticale	Surge	7.0	6.3	37	4	3358	556	17	NA	NA	NA
12	Barley	ND Genesis	7.7	7.7	50	6	4125	633	16	NA	NA	NA
13	Wheat	Linkert	7.0	6.3	37	5	1823	317	17	NA	NA	NA
14	Oats	Deon	8.3	8.3	47	6	4126	691	17	NA	NA	NA
	LSD @5% Level		1.5	1.9	9	1	420	46	3	NA	NA	NA
	CV(%)		13	16	17	13	60	45	9	NA	NA	NA

Experimental design:RCB with 3 reps

\*Frost prior to harvest reduced fresh weight

<sup>1</sup>Stand 9/22 - 9= ideal;1=no plants<sup>2</sup>Vigor 9/22 -9=best plant vigor;1=poor vigor<sup>3</sup>GC 10/7 = %ground cover

											Top Growth			Top Growth			Root Growth			Root Growth		
<b>Fallow -F4</b>											Fresh wt.	Dry wt.	%dry	Fresh wt.	Dry wt.	%dry	Fresh wt.	Dry wt.	%dry	Fresh wt.	Dry wt.	%dry
Treat#	Species	Variety	Stand <sup>1</sup>	Vigor <sup>2</sup>	%GC <sup>3</sup>	Ht(in.)	10/16	Frost <sup>4</sup>	#/acre	#/acre	#/acre	#/acre	#/acre	#/acre	#/acre	#/acre	#/acre	#/acre	#/acre	#/acre	#/acre	#/acre
						10/7	10/16		10/10	10/10	10/10	11/2	11/2	11/2	10/10	10/10	10/10	11/2	11/2	11/2	11/2	11/2
1	Canola	L340PC	8.0	9.0	88	7	8	1.0	11034	1391	12.7	15352	2687	16.9	NA	NA	NA	1660	470	24		
2	Radish	Tapmaster Daikon	8.0	9.0	88	6	7	3.5	10074	1199	11.9	12953	2111	16.2	1545	173	11	5066	528	11		
3	Rape	Barsica forage	7.5	8.0	73	6	6	4.3	7676	1045	13.7	NA	NA	NA	NA	NA	NA	NA	NA	NA		
4	Turnip	Barkant	9.0	9.0	65	7	7	4.5	13720	1641	12.0	14296	2207	15.6	911	144	14.1	3147	432	14		
5	pea	Austrian winter peas	8.0	9.0	55	5	3	1.0	3262	691	21.0	4989	959	19.9	NA	NA	NA	NA	NA	NA		
6	crimson clover	VNS	9.0	9.0	23	1	1	4.0	576	192	33.5	NA	NA	NA	NA	NA	NA	NA	NA	NA		
7	Red clover	Ruby	8.0	7.0	11	1	1	2.5	192	77	35.0	NA	NA	NA	NA	NA	NA	NA	NA	NA		
8	hairy vetch	190VNS	5.5	7.0	45	3	1	1.0	1439	336	21.5	NA	NA	NA	NA	NA	NA	NA	NA	NA		
9	buckwheat	VNS	9.0	9.0	66	9	3	10.0	959	998	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
10	Flax	Omega	9.0	9.0	33	4	5	3.3	1535	307	19.8	1727	575	32.5	NA	NA	NA	NA	NA	NA		
11	Triticale	Surge	7.0	7.5	69	7	8	2.0	7196	1238	17.5	12569	2399	18.8	NA	NA	NA	NA	NA	NA		
12	barley	ND Genesis	9.0	9.0	86	9	9	3.3	9979	1449	14.5	9787	2015	20.3	NA	NA	NA	NA	NA	NA		
13	wheat	Linkert	8.5	7.5	50	7	7	4.3	5660	1017	18.1	7196	1439	19.5	NA	NA	NA	NA	NA	NA		
14	oats	Laker-forage	9.0	9.0	73	9	6	6.5	7484	1238	16.5	6237	1343	21.9	NA	NA	NA	NA	NA	NA		
	LSD @5% Level		1.3	1.1	12	1	1	0.8	2591	345	3.0	3646	768	5.2	NA	NA	NA	NA	NA	NA		
	CV(%)		11	9	14	13	15	15	31	26	8	26	32	18	NA	NA	NA	NA	NA	NA		

Experimental design:RCB with 4 reps

3 row plots - rows 1' apart x 10'-17' long

All Planted 9/1/2022

Handed watered 5 days after planting

<sup>1</sup>Stand 9/22 - 9= ideal;1=no plants<sup>2</sup>Vigor 9/22 -9=best plant vigor;1=poor vigor<sup>3</sup>GC 10/7 = %ground cover<sup>4</sup>Frost damage 10/16-10=completely desiccated;1=no injury

frost damage-10-16-2022

canola 10%

radish 20%

rape 40%

turnip 5%

9/27=30F

9/28=31F

10/7 =22F

Soil test 9/15/2022	pH	OM	N1 lb	N2 lb	N-(N1+N2)	P-O ppm	K ppm
Wheat stubble F4	8	3.1	9	6	15	9	99
Fallow F8	7.8	2.8	28	48	76	13	134





Table 29.

**2022 P & K Large Plot Fertility Soybean Trial**  
**West Plant-Northern Resources-no yield data obtained in 2022**

**Soil Samples Taken 10/16/2022**

Treatment	P2O5 ppm	K2O ppm	Sulfur #/ac	Zinc ppm	%OM	PH	salt dS/m
Normal(1)	12.2	149	82	0.35	3.7	8.2	0.45
Plus 50(2)	19.5	151	74	0.37	3.7	8.2	0.44
LSD @5% level	10.0	22	67	NS	NS	NS	NS
LSD @10% level	7.5	16	50	0.04	NS	NS	NS
CV(%)	28	6.7	38	7.1	3.2	0.8	21

**Tissue Samples 7/6/2022**

%N	%P2O5	%K2O	%S	%Ca	%Mg	Zn ppm	Fe ppm	Mn ppm	Cu ppm	Boron ppm
5	0.41	2.5	0.31	1.86	0.79	22.0	389	100	9.3	28.5
5	0.43	2.6	0.32	1.84	0.77	19.0	306	95	8.0	28.8
NS	NS	NS	NS	NS	NS	NS	NS	NS	1.5	NS
NS	0.05	0.44	0.02	0.09	0.07	1.8	81	27	1.1	1.1
6.9	6.9	10.2	3.4	3.1	5.7	5.1	14	17	7.8	2.3

**2021 Wheat**

Treatment	West				West			Soil Test Levels 9-2021				West Plant		
	Braaten	Plant	Slater	Mean	Braaten	Plant	Mean	West	West	West	West	West	West	RCI
	Yield	Yield	Yield	Yield	Protein	Protein	Protein	P	P	K	K	Harvest	6/15	
Normal(1)	41.9	51.7	61.1	51.6	14.2	17	15.5	14	10	132	133	29	102	
Plus 50(2)	47.4	57.9	63.8	56.4	14.4	17	15.7	19	9	130	135	28.5	140	
LSD @5% level	0.4	NS	NS	5.2	0.1	NS	NS	NS	NS	NS	NS	NS	31	
LSD @10% level	0.3	5.3	NS	3.9	0.1	NS	NS	NS	NS	NS	NS	NS	21	
CV(%)	1	4	10	4	1	6	3	50	13	7	4	7	7	

**2020 Soybean Trial**

Treatment	West				West		West		West		West		West		West		West	
	Braaten	Plant	Slater	Mean	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant
	Yield(Bu./Acre)	Yield(Bu./Acre)	Yield(Bu./Acre)	Yield(Bu./Acre)	N %	P %	K %	S %	Ca %	Mg %	Zn ppm	Fe ppm	Mn ppm	Cu ppm	B ppm			
Normal(1)	30.6	43.5	50.0	41.4	5.8	5.1	0.39	0.38	1.4	2.3	0.30	0.30	1.47	1.13	0.64	0.48	25.8	20.8
Plus 50(2)	34.4	43.9	49.6	42.6	5.5	5.3	0.38	0.47	1.7	2.7	0.29	0.29	1.42	1.20	0.55	0.51	22.0	25.0
LSD @5% level	4	NS	NS	NS	0.4	0.2	0.05	0.06	0.3	0.3	0.03	0.03	0.20	0.09	0.09	0.03	6.4	3.3
LSD @10% level	3	NS	NS	NS	0.3	0.1	0.04	0.05	0.2	0.2	0.02	0.02	0.15	0.14	0.07	0.02	4.7	2.4
CV(%)	6	5	7	4	3	2	6	6	2	6	5	4	6	6	7	2	12	6

Braaten Farm Harvest and Soil Samples Taken 9/29/2020

Northern Resources Harvest and Soil Samples Taken 9/26/2020

Treatment	West		West		West		West		West		West		West		West		West	
	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant
	N #/ac	P ppm	K ppm	S #/ac	B ppm	Zn ppm	Mn ppm	Cu ppm	Mg ppm	Ca ppm	OM %	Salt dS/m	CEC meq/kg					
Normal(1)	10.5	7.5	7.8	7.3	119	115	101	120	0.98	1.15	0.37	0.27	2.1	1.4	0.56	0.41	844	1103
Plus 50(2)	11.8	7.5	5.3	6.0	107	107	64	120	0.95	1.03	0.29	0.3	1.7	1.7	0.51	0.48	777	1116
LSD @5% level	2.4	4.5	4.6	2.7	21	16	75	0	0.08	0.20	0.07	0.08	0.7	0.6	0.11	0.08	110	190
LSD @10% level	1.8	3.3	3.4	2.0	16	12	56	0	0.05	0.15	0.05	0.06	0.5	0.4	0.08	0.06	82	140
CV(%)	9	27	31	18	8	6	41	0	4	8	10	12	16	17	9	9	6	8

Soil test date- Both locations- 5/4/2020

Treatment	West		West		West		West		West		West		West		West		West	
	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant	Braaten	Plant
	N #/ac	P ppm	K ppm	S #/ac	B ppm	Zn ppm	Mn ppm	Cu ppm	Mg ppm	Ca ppm	OM %	Salt dS/m	CEC meq/kg					
11	9	10	6	155	148	84	120	1.2	1.2	0.48	0.34	2.8	1.8	0.66	0.46	937	927	

Braaten Farms P&K Tissue Samples Taken 7/30/20

Northern Resources Tissue Tests take 7/20/20

Seeding Date:  
 Braaten-- 5/22/2020  
 Northern Resources--6/2/2020  
 Slater--5/18/2020  
 Fertilizer sources:  
 Phosphorous(P)- 11-52-0  
 Potassium(K) -0-0-60  
 Fertilizer application dates:  
 Braaten-- 5/22/2020 Slater--5/18/2020  
 Northern Resources--6/1/2020



Table 31.

**Soybeans 2019-22**

TRT#	Added <sup>1</sup> P & K		Yield Bu./acre <sup>2</sup>				Test Wt./Bu.				Protein <sup>3</sup>				Oil <sup>3</sup>				Soil sampling-Post harvest by year						
	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022	2019	2020	2021	2022	P- ppm 2019	K- ppm 2019	P- ppm 2020	K- ppm 2020	P- ppm 2021	K- ppm 2021	P- ppm 2022	K- ppm 2022	
																									2019
1	0-20-0	65.3	64.8	46.0	54.1	57.4	57.7	59.7	59.4	36.7	38.7	37.7	40.0	20.4	20.9	20.6	19.7	17.0	122	4.5	120	17.0	117	4.5	148
2	0-40-0	62.0	69.0	44.3	47.2	57.5	57.7	59.4	59.9	37.1	38.9	37.9	40.2	20.4	20.7	20.9	19.5	19.5	119	4.5	113	17.0	112	7.0	140
3	0-60-0	61.5	65.0	46.3	50.6	57.2	57.8	59.4	59.6	37.4	38.8	37.6	40.2	20.5	20.9	20.8	19.3	18.8	123	8.0	117	17.2	120	11.8	136
4	0-80-0	61.0	65.5	48.3	48.8	57.5	57.8	59.5	59.7	36.9	38.2	36.5	39.9	19.6	21.2	21.3	19.4	22.0	128	10.3	123	20.5	115	8.8	145
5	0-100-0	63.8	69.0	50.9	52.0	57.1	57.8	59.5	59.2	37.8	38.6	38.5	39.9	20.3	20.9	20.6	19.4	19.0	132	13.8	113	27.8	129	16.5	135
6	0-0-20	61.8	61.0	48.3	48.7	57.3	57.7	59.5	59.6	37.0	38.5	37.3	39.7	20.4	20.9	20.2	19.6	15.0	117	4.5	111	10.5	113	3.3	139
7	0-0-40	63.5	69.0	50.7	49.9	57.5	57.7	59.3	59.2	37.0	38.5	36.9	39.3	20.4	20.9	20.9	20.0	15.7	128	3.3	114	11.5	137	4.0	138
8	0-0-60	67.5	63.2	54.1	50.2	57.5	57.8	59.4	59.0	36.9	38.5	35.5	39.3	20.2	21	21.1	20.0	16.8	123	2.5	125	10.8	133	4.5	149
9	0-0-80	61.5	66.3	47.2	47.1	57.5	57.7	59.4	59.3	37.0	38.3	37.4	39.6	20.0	21.0	21.1	19.8	14.5	127	3.0	134	12.7	129	4.0	154
10	0-0-100	68.0	66.5	51.7	51.1	57.4	57.6	59.2	58.9	37.0	38.6	37.9	39.5	20.3	20.9	20.7	20.2	16.8	126	2.8	131	10.0	125	4.0	150
11	0-20-20	67.8	69.8	48.0	57.5	57.3	57.6	59.3	59.2	36.9	38.6	36.4	40.2	20.3	20.9	21.0	19.7	19.3	128	4.0	126	13.0	108	4.5	140
12	0-40-40	64.3	68.3	46.4	55.4	57.5	57.9	59.5	59.4	36.7	38.5	38.6	39.6	20.0	20.9	20.9	19.8	18.5	120	6.3	118	14.5	118	7.0	149
13	0-60-60	64.3	69.3	48.2	53.8	57.4	57.8	59.3	59.3	37.0	38.6	35.8	39.1	20.5	21.0	21.1	19.6	20.3	132	7.0	123	22.2	131	8.3	146
14	0-80-80	62.3	63.5	51.1	53.9	57.5	57.7	59.5	59.5	37.2	38.5	37.6	38.9	20.3	21.0	20.9	19.9	22.0	125	9.5	126	20.5	126	9.8	144
15	0-100-100	68.5	63.8	48.2	57.8	57.3	57.6	59.2	59.6	37.4	39.0	36.9	39.7	20.2	21.0	21.3	19.5	20.0	121	9.0	132	27.3	124	13.3	150
16	0-0-0	61.7	61.0	46.0	52.1	57.3	57.7	59.4	59.0	36.9	39.1	38.0	39.7	19.9	20.7	21.2	20.1	17.5	121	3.3	109	12.5	110	4.3	142
LSD @ 5% Level		NS	8.3	7.5	6.7	0.4	NS	0.4	0.8	NS	0.4	1.4	0.9	NS	0.4	0.8	0.5	3.6	13	3.2	17	6.0	11	3.64	15.3
LSD @ 10% Level		6.4	6.5	6.2	6.1	0.3	0.3	0.3	0.7	0.8	0.4	2.0	0.8	0.8	0.3	0.6	0.4	3.0	11	2.6	14	5.0	9	3.04	12.8
CV(%)		8.5	7.8	10.8	9	0.5	0.4	0.5	0.9	1.8	0.8	3.5	1.7	2.3	1.3	2.6	1.9	13	7	37	10	26	6	35	8

TRT#	Added <sup>1</sup> P & K	Tissue Test Results <sup>5</sup>				Harvest Ht. (in.)				RCI <sup>6</sup>		Pop. (million) 6/22/22	soil						Tissue									
		P	K	2019	2020	2021	2022	8/17/21	2022	P	K		S	Zn	%OM	PH	Salts	B	Ca	Cu	I	Mg	Mn	N	P	K	S	Zn
1	0-20-0	0.48	1.9	28	24	29	36	535	265	0.207	4.5	148	15.5	0.33	3.3	7.8	0.27	32	1.69	7.25	214	1	120	4.98	0.41	2.03	0.29	19.5
2	0-40-0	0.48	1.7	28	24	30	34	605	282	0.194	7	140	14.5	0.32	3.1	7.8	0.24	33	1.76	7	225	1.05	126	5	0.46	1.9	0.29	17.8
3	0-60-0	0.5	1.9	28	24	30	37	606	272	0.177	11.8	136	16	0.34	3	7.9	0.26	33	1.75	7.5	233	1.03	115	4.62	0.45	2.15	0.28	17
4	0-80-0	0.5	1.9	28	24	29	35	614	275	0.172	8.8	145	16	0.35	3	7.9	0.25	32	1.76	7.25	260	1.04	124	4.79	0.46	2.03	0.29	20.3
5	0-100-0	0.47	2	28	25	29	37	578	264	0.191	16.5	135	15.5	0.35	3.2	7.7	0.24	34	1.71	6	203	1.03	119	4.87	0.54	1.95	0.29	14.5
6	0-0-20	0.47	1.9	28	24	27	35	442	263	0.161	3.3	139	16	0.31	3.2	7.9	0.26	30	1.74	8.75	241	0.94	124	4.85	0.4	2.23	0.3	22.5
7	0-0-40	0.45	2.1	29	24	28	35	394	255	0.193	4	138	15	0.33	3.3	7.8	0.26	31	1.68	8.5	221	0.91	117	4.77	0.39	2.23	0.29	21.3
8	0-0-60	0.48	2.3	28	23	28	34	429	268	0.188	4.5	149	14.5	0.32	3.2	7.8	0.26	30	1.69	8.25	218	0.89	116	4.69	0.37	2.33	0.27	21.8
9	0-0-80	0.48	2.2	28	24	28	34	476	262	0.185	4	154	15.5	0.32	3.3	7.9	0.26	29	1.69	9.25	273	0.86	122	4.92	0.39	2.35	0.29	25.8
10	0-0-100	0.49	2.3	27	24	29	34	577	267	0.177	4	150	15	0.32	3.3	7.8	0.25	29	1.63	8.75	285	0.87	115	4.85	0.39	2.23	0.28	25.8
11	0-20-20	0.49	2.1	30	25	29	36	577	276	0.194	4.5	140	18	0.33	3.2	7.9	0.24	31	1.77	8.25	186	1	116	4.74	0.41	2.25	0.29	20
12	0-40-40	0.5	2.1	28	25	29	37	574	280	0.172	7	149	16	0.36	3.2	7.8	0.27	30	1.65	7	180	0.9	110	4.7	0.43	2.23	0.28	16.5
13	0-60-60	0.5	2.1	28	25	29	36	618	267	0.191	8.3	146	16	0.35	3.3	7.8	0.26	30	1.66	7.25	187	0.93	100	4.44	0.4	2.23	0.27	17.8
14	0-80-80	0.47	2.1	28	24	30	35	663	267	0.158	9.8	144	14.5	0.34	3.1	7.8	0.27	31	1.69	6	162	0.94	109	4.43	0.46	2.5	0.28	14.3
15	0-100-100	0.5	2.2	30	24	30	36	628	251	0.18	13.3	150	16	0.36	3.1	7.8	0.26	31	1.67	6	180	0.88	121	4.57	0.46	2.23	0.27	14.3
16	0-0-0	0.49	1.9	28	24	27	35	451	270	0.204	4.3	142	16	0.34	3.3	7.8	0.26	31	1.58	7.25	193	0.91	109	4.74	0.4	2.1	0.28	19.5
LSD @ 5% Level		0.03	0.2	NS	NS	2	2	65	37	0.0639	3.64	15.3	2.56	0.03	0.21	0.08	0.03	2.78	0.14	1.52	83.3	0.1	17.4	0.32	0.06	0.28	0.02	4.98
LSD @ 10% Level		0.02	0.1	2	2	1	3	80	30	0.058	3.04	12.8	2.14	0.02	0.18	0.07	0.02	2.32	0.12	1.26	69.4	0.08	14.5	0.27	0.05	0.23	0.02	4.15
CV(%)		5	6	6	6	3	4	12	10	12	35	8	12	7	5	1	7	6	6	14	27	7	11	5	9	9	6	18

Experimental Design: RCB with 4 reps

All plots us best management practices(BPM)

Soybean variety - AG005x1 seeded at 1.4 units/ac; 172,000 PLS/ac on 05/13/21 ;

Asgrow AG005x8 soybeans seeded @ 225,000/acre 5/17/2019

<sup>1</sup>Added - 0-46-0 super phosphate and 0-0-60 potash used for P and K sources

Soybean variety - AG005xF2 seeded at 1.5 units/ac; 210,000 PLS/ac on 6/9/2022.

<sup>2</sup>Yield - Bushels per acre corrected to 12% moisture for wheat and 13% moisture for soybean

Linkert wheat seeded @ 120#/acre 5/28/2022.

<sup>3</sup>Protein and Oil-on dry matter basis

Fertilizer added<sup>1</sup>- 0-46-0 super phosphate and 0-0-60 potash used for P and K sources.

Plot size= 6' x 15'

Yield<sup>2</sup>-Bushels per acre corrected to 12% moisture for wheat and 13% moisture for soybean.

Soil Type-Borup silt loam(2021 wheat) Zippel very fine clay loam(2021 soybeans)

Protein and Oil<sup>3</sup>-on dry matter basis.

<sup>4</sup>Soil test result - in parts per million(PPM) Olsen P test and K test. Samples taken 9/14/2021 after harvest

RCI<sup>6</sup>- Relative chlorophyll index-higher number = more chlorophyll.

<sup>5</sup>Tissue samples - Expressed in %. Wheat- late tillering on 06/14/21; soybeans- early flower 7/5/2021

Color<sup>5</sup>-1=light green - 3=Dark green.

<sup>6</sup>RCI- Relative chlorophyll index-higher number = more chlorophyll

Plant pop<sup>6</sup>- Plant count in Millions per acre on 6-22-2022.

Plot size= 6' x 15'

Soil Type-Borup silt loam(2021 wheat) Zippel very fine clay loam(2021 soybeans)

Baseline 5/7/2019	PH	% OM	Olsen P ppm	NH4OAc-K ppm	SO4-S #/ac	Zn ppm	nitrate #/acre	Sol salts
Soil tests-0-6"								
F7SE(wheat in 2019)	8.2	2.8	6	154	14	0.27	9	0.23
F7NW(soybean in 2019)	7.8	2.8	23	166	34	0.38	NA	0.4

Table 32.

**2022 P & K Long Term Fertility Rotation Trial on Spring Wheat and Soybeans  
U of MN, Magnusson Research Farm Roseau, MN**

**Wheat 2019-22**

TRT#	P & K	Yield Bu./acre <sup>2</sup>		Test Wt./Bu.				Protein <sup>3</sup>				Soil Test Results <sup>4</sup>		Tissue Test Results <sup>5</sup>		Soil								
		2019	2021	2019	2020	2021	2022	2019	2020	2021	2022	P	K	P	K	P	K	S	Zn	%OM	PH	Salts		
		2020	2022	2020	2021	2022	2020	2021	2022	2020	2021	2022	2020	2021	2020	2021	2020	2021	2022	2020	2021	2022		
1	0-20-0	85.0	73.0	72.6	75.5	60.3	63.0	61.9	60.6	15.3	14.7	16.9	16.6	5.5	130	0.36	2.9	15.5	94	21	0.28	2.9	8.1	0.23
2	0-40-0	86.3	75.8	79.6	78.1	60.3	62.3	62.0	60.8	15.3	14.6	16.8	16.7	8.5	125	0.39	3.1	15.8	94	27	0.29	2.6	8.2	0.24
3	0-60-0	87.3	72.8	78.6	76.5	60.2	62.3	62.0	60.5	15.1	14.5	17.0	16.8	9.5	125	0.41	2.8	23.8	91	19	0.30	3.0	8.1	0.22
4	0-80-0	85.3	69.8	80.0	79.0	60.3	62.7	62.0	60.7	15.1	14.3	16.6	16.8	12.5	128	0.45	3.0	29.3	94	25	0.30	2.9	8.0	0.24
5	0-100-0	92.8	67.8	79.0	78.2	60.2	62.7	61.4	60.5	15.2	14.0	17.0	16.7	16.8	119	0.45	2.7	26.5	107	18	0.34	2.6	8.1	0.21
6	0-0-20	81.3	70.5	64.3	74.3	60.0	62.1	62.2	60.7	15.4	14.4	17.0	16.9	4.0	121	0.33	3.0	10.5	99	19	0.27	3.1	8.1	0.22
7	0-0-40	81.5	69.3	63.2	74.7	60.0	62.9	61.9	60.7	15.4	14.6	17.3	16.8	5.0	127	0.32	3.3	12.8	109	21	0.28	3.1	8.1	0.23
8	0-0-60	83.3	69.5	60.3	75.0	60.0	63.1	62.1	60.8	15.5	14.5	17.3	16.9	4.5	132	0.32	3.6	10.5	114	23	0.27	2.3	8.1	0.24
9	0-0-80	81.3	70.3	60.7	77.2	60.3	62.4	62.3	60.7	15.7	14.9	17.4	17.0	4.8	147	0.3	3.7	11.3	114	20	0.29	2.4	8.1	0.22
10	0-0-100	82.5	71.3	59.0	78.2	60.1	63.1	62.2	61.0	15.7	14.5	17.1	17.1	3.8	136	0.32	4.0	11.0	117	38	0.29	2.4	8.0	0.25
11	0-20-20	89.0	70.5	75.9	73.7	60.1	63.0	62.2	60.5	15.3	14.5	17.1	16.6	6.0	126	0.35	3.2	12.0	86	19	0.26	2.4	8.1	0.21
12	0-40-40	86.5	74.8	80.5	78.7	60.1	62.1	61.8	60.7	15.2	14.2	16.8	16.7	10.8	135	0.39	3.3	19.5	97	21	0.28	2.5	8.1	0.22
13	0-60-60	85.3	73.3	82.4	81.1	60.2	61.7	62.2	60.9	15.1	14.4	17.1	16.7	12.5	125	0.43	3.5	21.5	93	21	0.27	2.4	8.1	0.22
14	0-80-80	77.5	76.0	82.8	79.3	60.0	62.8	62.3	60.7	15.3	14.6	17.1	16.9	19.5	130	0.43	3.4	22.5	98	21	0.29	2.9	8.1	0.22
15	0-100-100	87.8	74.0	84.8	77.9	60.3	62.6	62.0	61.1	15.2	14.4	17.1	16.9	19.8	139	0.44	3.5	27.3	104	18	0.30	2.4	8.0	0.22
16	0-0-0	82.3	67.0	60.0	77.4	60.2	62.6	61.7	60.5	15.3	14.7	17.0	16.7	3.7	120	0.33	3.0	12.3	95	21	0.26	2.5	8.1	0.20
LSD @ 5% Level		8.6	7.4	7	3.9	0.3	1.3	0.6	0.4	0.2	0.7	0.7	0.3	3.8	12	0.05	0.3	4.1	20.1	15.1	0.03	0.7	0.2	0.1
LSD @ 10% Level		7.2	6.2	5.8	3.2	0.2	1.1	0.5	0.3	0.2	0.5	0.6	0.3	3.1	10	0.04	0.2	3.5	16.7	12.5	0.03	0.6	0.2	0.1
CV(%)		7.2	7.2	6.7	3.5	0.3	1.5	0.6	0.5	1.1	3.2	3.0	1.2	28	6	9	7	16	14	49	8	17	1.3	14

Linkert wheat seeded @ 120#/acre 5/11/2019  
160-0-0 applied and incorporated in final seedbed prep.

**2022**

TRT#	P & K	Tissue											Ht. (in.)			RCI <sup>6</sup>			Plant Pop. (million)			
		B	Ca	Ch	Cu	Phos	I	Mg	Mn	N	P	K	Na	S	Zn	2019	2021	2022		7/20/20	6/15/21	6/15/22
1	0-20-0	3.50	0.46	0.20	8.30	15.30	273	0.52	56	5.99	0.53	3.78	0.11	0.31	20	30	29	29	493	241	340	1.264
2	0-40-0	4.30	0.45	0.36	7.80	12.00	282	0.49	58	6.00	0.53	3.95	0.09	0.33	20	30	29	29	491	253	381	1.296
3	0-60-0	2.80	0.39	0.24	8.00	11.00	258	0.53	52	6.20	0.52	3.73	0.11	0.35	19	30	31	29	411	263	323	1.296
4	0-80-0	3.30	0.42	0.21	8.00	16.80	251	0.54	53	6.20	0.57	3.65	0.11	0.36	19	30	31	28	435	221	360	1.306
5	0-100-0	3.00	0.44	0.23	8.30	14.80	259	0.51	55	6.20	0.59	4.18	0.05	0.38	20	29	31	30	410	236	360	1.264
6	0-0-20	2.80	0.42	0.71	7.50	11.30	279	0.45	59	5.80	0.50	4.08	0.03	0.30	20	30	32	28	459	296	284	1.264
7	0-0-40	3.00	0.42	0.80	8.30	9.50	304	0.47	56	5.70	0.50	4.33	0.03	0.32	21	29	33	29	421	295	313	1.166
8	0-0-60	3.00	0.39	0.88	7.80	6.80	279	0.44	55	5.70	0.48	4.50	0.02	0.31	20	30	34	28	373	348	251	1.188
9	0-0-80	3.00	0.39	0.92	7.80	8.50	277	0.44	59	5.70	0.49	4.45	0.03	0.31	21	30	31	28	404	268	275	1.264
10	0-0-100	3.00	0.42	0.93	7.50	10.30	272	0.41	60	5.60	0.49	4.38	0.02	0.29	22	30	32	28	439	303	299	1.372
11	0-20-20	3.30	0.42	0.76	8.00	8.30	256	0.48	56	5.80	0.48	3.95	0.06	0.32	20	30	30	28	391	289	332	1.426
12	0-40-40	3.00	0.41	0.80	7.80	11.80	255	0.48	58	5.90	0.53	4.30	0.04	0.33	20	30	30	29	428	219	355	1.296
13	0-60-60	3.00	0.42	0.84	7.50	13.00	258	0.46	59	5.90	0.54	4.10	0.03	0.33	19	30	29	29	415	259	379	1.154
14	0-80-80	3.30	0.38	0.83	7.50	9.80	273	0.44	58	6.00	0.54	4.30	0.04	0.36	19	30	32	29	472	267	338	1.34
15	0-100-100	4.30	0.40	0.86	7.80	13.50	260	0.43	56	5.90	0.57	4.45	0.04	0.35	19	29	30	29	408	308	328	1.296
16	0-0-0	3.80	0.49	0.15	7.80	18.30	269	0.50	57	5.90	0.53	3.88	0.06	0.28	23	31	29	29	395	245	291	1.296
LSD @ 5% Level		0.95	0.06	0.14	0.96	6.13	35	0.06	6	0.15	0.05	0.39	0.06	0.03	2	1	4	1	59	88	77	0.182
LSD @ 10% Level		0.80	0.05	0.11	0.79	5.09	30	0.05	5	0.11	0.04	0.34	0.05	0.03	1	1	3	1	50	78	66	0.15
CV(%)		20.6	10	16	8.6	6.2	9	9	8	2	36	6.6	82	6.5	5.5	3	9	3	10	24	16	16

Table 33.

**2021-2 Rye and Winter Wheat P and K Fertility**  
**Magnusson Research farm**

TRT#	Crop	Fertilizer Added	Yield Bu./acre <sup>1</sup>			Test wt.		RCI <sup>3</sup>		5/11/22		6/17		Harvest	
			2022	2021	Average	Protein	#/Bu.	Ergot <sup>2</sup>	6/3	6/17	Vigor <sup>4</sup>	%stand	color <sup>5</sup>	lodging <sup>6</sup>	Ht(in.)
1	Jerry-ww	0	65.8	83	74.4	15.1	60.5	0.0	349	614	2.8	76	8	3.8	40
2	Jerry-ww	0-20-20	63.1	83	73.1	15.6	60.2	0.0	326	604	2.3	68	8	4.0	38
3	Jerry-ww	0-40-40	64.8	82	73.4	15.3	60.6	0.0	305	635	2.5	74	8	3.8	38
4	Jerry-ww	0-60-60	65.0	88	76.5	15.1	60.7	0.0	342	680	2.8	73	8	4.0	39
5	Jerry-ww	0-80-80	64.3	85	74.7	15.1	60.6	0.0	315	640	2.8	76	8	4.3	38
6	Rymin rye	0	97.7	85	91.4	16.0	55.1	1.5	561	468	3.8	88	6	4.5	53
7	Rymin rye	0-20-20	94.8	88	91.4	16.1	54.8	1.6	532	497	3.5	90	6	4.3	53
8	Rymin rye	0-40-40	95.8	86	90.9	16.1	54.6	2.0	571	450	4.0	93	6	4.8	51
9	Rymin rye	0-60-60	93.4	91	92.2	16.0	55.0	1.8	591	422	3.8	85	6	4.8	51
10	Rymin rye	0-80-80	91.9	83	87.5	16.2	54.8	2.3	623	395	4.0	91	6	5.8	52
11	KWS Serafino rye	0	151.3	123	137.2	13.4	56.5	0.4	544	570	3.8	89	7	1.3	51
12	KWS Serafino rye	0-20-20	155.5	133	144.3	13.2	55.9	0.4	541	713	3.5	88	7	1.0	49
13	KWS Serafino rye	0-40-40	156.7	137	146.9	13.3	56.5	0.4	525	671	3.8	88	7	1.3	52
14	KWS Serafino rye	0-60-60	159.0	139	149.0	12.9	56.4	0.1	623	642	4.0	90	7	1.5	52
15	KWS Serafino rye	0-80-80	160.4	140	150.2	13.1	56.6	0.3	520	615	3.5	83	7	1.0	51
LSD @5% level			13	10	9.8	0.9	0.7	0.9	81	92	0.8	12	0	1.8	3
CV(%)			8.7	7	7	4.5	0.85	84	11	11	16	10	0	39	5

TRT#	Crop	Fertilizer Added	soil test post harvest 9/14/2022																
			PH	OM	N-ppm	P-O ppm	K ppm	Ca ppm	Mg ppm	Na	S	Zn	salts	Cu	B	Fe	Mn	CEC	%CEC
1	Jerry-ww	0	8.2	3.3	8	6.3	93	2401	767	25	19	0.25	0.22	0.33	0.61	8.1	0.96	18.7	0.53
2	Jerry-ww	0-20-20	8.1	3.2	7	7.0	91	2195	708	19	20	0.22	0.20	0.29	0.54	7.2	0.85	17.2	0.58
3	Jerry-ww	0-40-40	8.1	3.2	7	7.5	96	2237	730	21	18	0.23	0.20	0.31	0.55	8.0	0.91	17.6	0.33
4	Jerry-ww	0-60-60	8.0	3.3	10	11.5	109	2381	746	22	18	0.27	0.18	0.35	0.61	9.1	1.00	18.5	0.35
5	Jerry-ww	0-80-80	8.1	3.2	9	12.3	97	2311	731	23	20	0.24	0.21	0.30	0.53	8.1	0.86	18.0	0.43
6	Rymin rye	0	8.0	3.1	11	4.3	92	2238	700	21	18	0.22	0.21	0.30	0.53	8.4	1.08	17.4	0.45
7	Rymin rye	0-20-20	8.1	3.1	11	5.0	90	2249	713	21	17	0.22	0.21	0.30	0.54	7.9	1.04	17.5	0.33
8	Rymin rye	0-40-40	8.0	3.2	10	6.0	93	2168	696	17	18	0.25	0.19	0.32	0.56	8.6	1.06	17.0	0.43
9	Rymin rye	0-60-60	8.0	3.1	10	5.0	92	2356	713	18	18	0.24	0.17	0.33	0.56	8.7	1.07	18.0	0.55
10	Rymin rye	0-80-80	7.9	3.1	13	8.5	92	2197	665	18	18	0.26	0.18	0.32	0.55	8.6	1.00	16.8	0.25
11	KWS Serafino rye	0	8.0	3.1	10	4.3	84	2190	657	19	19	0.24	0.19	0.31	0.52	8.8	1.20	16.7	0.30
12	KWS Serafino rye	0-20-20	7.9	3.3	11	7.0	87	2224	683	18	18	0.24	0.20	0.31	0.54	8.1	0.90	17.1	0.20
13	KWS Serafino rye	0-40-40	7.9	3.3	10	6.0	90	2238	704	22	19	0.26	0.19	0.33	0.59	9.0	1.08	17.4	0.33
14	KWS Serafino rye	0-60-60	8.0	3.3	11	9.0	88	2134	677	19	18	0.23	0.21	0.29	0.52	8.0	0.87	16.6	0.23
15	KWS Serafino rye	0-80-80	8.0	3.1	8	8.0	82	2173	687	19	19	0.25	0.19	0.31	0.54	8.6	0.98	16.9	0.28
LSD @5% level			0.1	0.3	3	3.5	11	263	98	6	3	0.05	0.05	0.04	0.08	1.6	0.15	2.0	0.28
CV(%)			1	7	22	34	8	8	10	22	12	14	17	9	10	14	11	8	53

TRT#	Crop	Fertilizer Added	Tissue Sample 6/16/2022															
			%N	%P	%K	%S	%Ca	%Mg	Zn-ppm	Fe-ppm	Mn-ppm	Cu-ppm	B-ppm					
1	Jerry-ww	0	5.0	0.32	1.85	0.38	0.37	0.33	17	111	43	5.0	4.3					
2	Jerry-ww	0-20-20	5.0	0.34	2.02	0.37	0.36	0.30	18	112	43	5.5	4.3					
3	Jerry-ww	0-40-40	5.1	0.34	1.93	0.40	0.40	0.32	17	122	43	5.3	3.8					
4	Jerry-ww	0-60-60	5.0	0.35	2.03	0.35	0.39	0.32	16	117	44	5.8	4.0					
5	Jerry-ww	0-80-80	5.1	0.36	2.03	0.40	0.38	0.32	16	120	44	5.5	4.0					
6	Rymin rye	0	4.4	0.23	1.08	0.36	1.35	0.70	14	117	57	6.8	8.0					
7	Rymin rye	0-20-20	4.6	0.24	1.04	0.40	1.36	0.74	15	115	62	7.0	8.3					
8	Rymin rye	0-40-40	4.6	0.25	1.05	0.38	1.39	0.72	15	121	54	7.0	7.5					
9	Rymin rye	0-60-60	4.5	0.25	1.09	0.38	1.39	0.74	14	124	55	7.0	8.0					
10	Rymin rye	0-80-80	4.6	0.25	1.06	0.38	1.35	0.67	14	120	53	6.8	8.0					
11	KWS Serafino rye	0	4.8	0.27	1.28	0.44	1.26	0.58	15	123	61	8.5	9.5					
12	KWS Serafino rye	0-20-20	5.1	0.28	1.21	0.45	1.31	0.65	16	138	54	9.0	7.3					
13	KWS Serafino rye	0-40-40	5.0	0.27	1.07	0.45	1.31	0.62	15	124	61	8.5	8.0					
14	KWS Serafino rye	0-60-60	4.9	0.27	1.1	0.43	1.32	0.62	15	126	57	8.5	7.5					
15	KWS Serafino rye	0-80-80	4.9	0.28	1.13	0.46	1.31	0.63	16	130	60	9.0	8.0					
LSD @5% level			0.15	0.02	0.17	0.05	0.19	0.10	2	13	10	1.4	1.2					
CV(%)			2	6	9	9	13	13	8	8	13	14	13					

Experimental Design=RCB w 4 reps

Fertilizer applied prior to planting 9/10/2021 and planted 9/15/2021.

Fertility source= 11-52-0 and 0-0-60

All remaining nitrogen applied in spring

120-0-0 hand applied to all plots 5/19/2022

<sup>1</sup>-Yield adjusted to 12% moisture<sup>2</sup>Ergot-visual estimate of ergot-1=.1%ergot<sup>3</sup>RCI-Relative chlorophyll index-higher number =more relative amounts of chlorophyll<sup>4</sup>Vigor-1=poor plant vigor;5=good vigor<sup>5</sup>color-1=light green;9=dark green<sup>6</sup>lodging-1=no lodging;9=flat

Past crop=Soybeans in 2020

## Soil test 10/2021

0-6"		6-24"		Total	Soil test depth = 0-6"					
nitrate	nitrate	nitrate	P	K	s	zn	%OM	PH	%cce	
4	6	10	7	106	16	0.23	2.1	8.1	0.3	

Table 34.

## 2022 Hybrid Rye Nitrogen Rate Trial Magnusson Farms

TRT#	Nitrogen Rate <sup>1</sup>	Bu./acre Yield <sup>2</sup>			3 year Average	Test wt. #/Bu.	Ergot <sup>3</sup>	RCI <sup>4</sup>		Color <sup>5</sup>	Harvest Ht(in.)
		2022	2021	2020				6/3/22	6/15/22		
1	0	36.8	50.9	29.2	39	53.9	1.7	157	243	1.8	44
2	40-0-0	76.9	78.3	69.7	75	54.2	0.7	285	427	5.0	48
3	80-0-0	95.5	93.3	83.0	90	54.2	0.2	378	528	6.0	50
4	120-0-0	89.1	103.8	85.7	93	53.7	0.7	382	602	7.8	48
5	160-0-0	83.5	103.9	86.2	91	53.4	1.2	363	610	7.0	50
6	200-0-0	91.6	101.3	94.1	96	53.7	0.5	406	618	7.8	50
7	200-0-0+PGR <sup>a</sup>	94.4	NA	NA	NA	52.6	1.0	395	664	8.0	46
8	120-0-0-30S	93.4	103.7	90.8	96	53.7	0.5	386	613	7.5	51
LSD @5% level		15	13.1	9.8	9	0.6	1.2	71	66	0.9	3
CV(%)		12.4	9.7	8	8	0.8	95	14	8	9	4

Aerial spring application adjacent to plot area=70 bushels/acre

50# N added to aerial application=91 bushels/acre

TRT#	Nitrogen Rate <sup>1</sup>	Tissue Sample- flag leaf Early heading 6-7-2021									
		%N	%P	%K	%S	%Ca	%Mg	Zn-ppm	Mn-ppm	Cu-ppm	B-ppm
1	0	4.6	0.22	1.05	0.35	0.75	0.48	14	38	8.3	6.3
2	40-0-0	4.6	0.24	1.06	0.35	0.89	0.53	15	42	8.3	7.3
3	80-0-0	4.5	0.23	1.13	0.33	0.81	0.52	16	37	8.3	7.3
4	120-0-0	5.1	0.24	1.02	0.38	0.93	0.56	16	43	8.5	6.5
5	160-0-0	5.0	0.25	1.06	0.39	0.81	0.50	15	42	9.0	6.5
6	200-0-0	5.2	0.25	1.03	0.41	1.03	0.57	16	49	9.0	7.0
7	200-0-0+PGR <sup>a</sup>	4.9	0.23	0.96	0.38	0.99	0.54	15	48	8.3	7.5
8	120-0-0-30S	4.8	0.24	1.19	0.56	0.98	0.65	19	40	9.5	6.8
LSD @5% level		0.6	0.02	0.17	0.07	0.23	0.12	2	9	1	NS
CV(%)		9	7	11	12	17	15	9	15	8	20

Experimental Design=RCB w 4 reps Variety=Tayo

Nitrogen Fertilizer applications made 5/10/2022

<sup>1</sup>Nitrogen Rate-All N rates are #N/acre- urea source. Trt#8 has 30# sulfur(AMS) added. Trt#7 had 12oz.

<sup>a</sup>Palisade 1EC 12 oz./ac + .25%NIS applied 5/27/2022 sunny,65F ENE 5-8mph-feeks 4-12" G height

<sup>2</sup>Yield adjusted to 12% moisture. Magnusson Farms in 2021 as well and Amundson farms 2020.

Variety=Tayo-2022 ; Serafino 2021; Brassetto 2020

<sup>3</sup>Ergot-visual rating of harvested seed. 1=0.1%ergot.

<sup>4</sup>RCI Relative chlorophyll index- Higher number means higher level of chlorophyll

<sup>5</sup>Color-visual rating: 9= dark green;1=light green

Past crop-canola in 2021.

Soil test- 10/2021

0-6"	6-24"	Soil test depth = 0-6"				
nitrate	nitrate	P	K	%OM	PH	%cce
13	NA	4L	145M	3.4L	7.7	.4VL

Table 35.

**2021-2 Rye Micronutrient Application For Ergot Reduction  
Magnusson Research Farm**

Trt <sup>1</sup>	Treatment/Formulation	Application		Yield Bu/acre <sup>2</sup>		Test Wt		%Stand <sup>4</sup>	Vigor <sup>5</sup>	RCI <sup>6</sup>		Color <sup>7</sup>	Harvest
		Timing	Rate/ac	2022	2021	#/bu.	Ergot <sup>3</sup>			5/11/22	6/3/22		
1	No Treat	-----	-----	141.7	92.7	56.7	1.4	89	4.5	578	616	7.5	53
2	3-0-0-6%Mn 13%	5-Oct	2pt	147.7	91.1	56.7	0.9	92	4.5	548	668	7.5	53
3	MnSO <sub>4</sub> 27%	5-Oct	4#	146.0	91.0	56.8	1.0	91	4.8	598	608	7.5	53
4	Badge SC 2.27#/gal	22-May	2pt	145.9	-----	56.6	1.1	93	4.8	589	606	7.5	53
LSD @5% level				7(ns)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV(%)				3	7	0.3	36	6	11	10	14	0	3

6-6-2022 boot stage whole plant tissue samples													
Treatment	Application		B	Ca	Cu	Fe	Mg	Mn	Total-N	P	K	S	Zn
	Timing	Rate/ac	ppm	%	ppm	ppm	%	ppm	%	%	%	%	ppm
No Treat	-----	-----	9.5	0.56	9.8	82	0.34	49.3	4.8	0.29	1.7	0.31	14.8
3-0-0-6%Mn	5-Oct	2pt	9.5	0.57	9.0	84	0.35	47.3	4.9	0.29	1.7	0.31	14.0
MnSO <sub>4</sub>	5-Oct	4#	9.3	0.51	9.8	80	0.32	45.6	4.8	0.27	1.6	0.29	13.8
Badge SC	22-May	2pt	8.5	0.49	13.3	75	0.3	42.5	4.9	0.26	1.5	0.28	12.8
LSD @5% level			NS	0.08	1.7	NS	NS	NS	NS	NS	NS	NS	NS
CV(%)			18	10	11	11	11	11	2	10	11	12	12

Experimental Design=RCB w 4 reps Variety=Serafino

120-50-50 applied to all plots 5/19/22

<sup>1</sup>Trt= 2&3 applied 10/5/2022 after emergence

Badge applied 5/22 rye 5-7" tillering 7pm 57F 8 mph wnw 31%RH clear full sun

Badge SC copper hydroxide + copper oxychloride 2.27# metallic copper/gal.

<sup>2</sup>Bu./Ac.= Clean seed yield @13% moisture. Border plot yield with no added micro nutrients and 120-0-0=146.3 bu./acre

<sup>3</sup>Ergot=Visual estimate of ergot-1=0.1% ergot estimate

<sup>4</sup>%Stand=Visual % rating of full stand

<sup>5</sup>Vigor=5= best;1=least

<sup>6</sup>RCI=Relative chlorophyll index- higher number = more relative amount of chlorophyll.

<sup>7</sup>Color=9-dark green;1=light green





Table 38.

### Armyworm Moth Trapping Project in Roseau County Summary Report - 2021 & 2022

#### True Armyworm (*Mythimna unipuncta*) moth capture at six locations in Roseau County in 2022

Date	Location						Total
	1	2	3	4	5	6	
28-May	0	12	0	6	0	*	18
29-May	3	0	0	0	1	*	4
31-May	14	3	0	0	0	*	17
1-Jun	0	0	0	0	10	*	10
12-Jun	19	8	9	0	11	0	47
14-Jun	5	0	1	2	17	6	31
18-Jun	10	2	5	0	4	0	21
20-Jun	10	5	1	0	9	8	33
26-Jun	0	15	1	7	7	0	30
2-Jul	19	18	6	10	0	0	53
4-Jul	0	0	0	0	22	0	22
8-Jul	0	0	0	0	0	10	10
11-Jul	13	0	0	0	0	2	15
<b>Total</b>	<b>93</b>	<b>63</b>	<b>23</b>	<b>25</b>	<b>81</b>	<b>26</b>	<b>311</b>

\*Armyworm trap placed in the field on June 1, 2022

This armyworm moth trapping project will continue in 2023.

In 2023, perennial ryegrass fields will be the focus as in the last two years, armyworm trapping indicated that moth flights into northern MN during May June and July seem to have a preference for perennial ryegrass field compared to other grass crops.

#### The six armyworm moth trapping locations in 2022:

**Location 1:** Dieter Township, Section 34, SE quarter. Trap placed in the middle of a perennial ryegrass field.

**Location 2:** Jadis Township, Section 15, SW quarter. Trap placed in the middle of a perennial ryegrass field.

**Location 3:** Jadis Township, Section 9, SE quarter. Trap placed in the border of a hybrid rye and a perennial ryegrass field.

**Location 4:** Jadis Township, Section 5, SW quarter. Trap placed in the border of a Ky. bluegrass and a per. ryegrass field.

**Location 5:** Laona Township, Section 10, NE quarter. Trap was in a field boundary of two perennial ryegrass seed field.

**Location 6:** Jadis Addition, Section 32, SE quarter. Trap was in middle of a Kentucky bluegrass seed field.

In 2022, this armyworm moth trapping project documented four flights with moth captures that averaged over 3 moths/night.

The calendar dates and the number of moths collected were:

- May 28 - June 1 = 49
- June 12-14 = 78
- June 18-20 = 54
- July 2-4 = 53

#### Armyworm moth capture at four location in Roseau County in 2021

Date	Location				Total
	1	2	3	4	
18-May	4	0	0	0	4
21-May	14	10	0	2	26
23-May	15	11	9	1	36
25-May	7	0	0	4	11
29-May	8	2	0	3	13
31-May	1	0	3	0	4
3-Jun	2	0	0	1	3
11-Jun	0	0	1	1	2
13-Jun	4	4	0	2	10
15-Jun	4 + 2*	3 + 2*	7	5	19
17-Jun	2	2 + 1*	0	3	7
20-Jun	0	1	4	0	5
24-Jun	0	0	0	0	0
<b>Total</b>	<b>61</b>	<b>33</b>	<b>24</b>	<b>22</b>	<b>140</b>

\*Spotted cutworm moth

Thirty eight moths were captured in a trap at the U of MN-Magnusson Research Farm from July 22-25.

#### The four armyworm moth trapping locations in 2021:

**Location 1:** Jadis Township, Section 5, SW quarter.

Trap placed in the middle of ryegrass field.

**Location 2:** Jadis Township, Section 9, NE quarter. Trap in a field border between a Kentucky bluegrass and perennial ryegrass seed field.

**Location 3:** Laona Township, Section 10, NE quarter.

Trap was in field a boundary of spring wheat and a perennial ryegrass seed field.

**Location 4:** Jadis Addition, Section 32, SE quarter.

Trap was in middle of a Kentucky bluegrass seed field.