IMPROVING SMALL GRAINS VARIETIES FOR NEBRASKA

2017 STATE BREEDING AND QUALITY EVALUATION REPORT

Report to the

NEBRASKA WHEAT DEVELOPMENT, UTILIZATION
AND MARKETING BOARD

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2017 STATE BREEDING AND QUALITY EVALUATION REPORT

I. INTRODUCTION

Development research on Nebraska's wheat varieties is a cooperative effort between the Agricultural Research Division, IANR of the University of Nebraska-Lincoln, and the Agricultural Research Service/USDA, Northern Plains Area. Winter wheat breeding, which includes variety, line, and germplasm development, is a major component of the state's wheat improvement research. This report deals only with the state portion of the total wheat breeding effort (located in the Department of Agronomy and Horticulture at the University of Nebraska-Lincoln). Key contributions come from state and federal researchers and from Nebraska research and extension centers, as well as from state and private researchers in South Dakota, Wyoming, Kansas, Oklahoma, Texas, and Colorado. Other important contributions come from researchers in the Department of Plant Pathology (both state and federal); plant pathologists located at the USDA Cereal Disease Laboratory in St. Paul, MN, and USDA entomologists in Manhattan, KS and Stillwater, OK. All of these programs invest time and funds into this program. Grants from the Nebraska Wheat Development, Utilization and Marketing Board, provide key financial support for this research. Without the Wheat Board's support, much of the state breeding efforts would be limited and many of the wheat quality analyses to evaluate our breeding material would not be available.

II. THE 2016-2017 NEBRASKA WHEAT CROP

1. Growing Conditions

The 2016-2017 growing season would be considered being generally good for production in many areas with significant challenges in some regions. Growing conditions included timely planting into generally good soil moisture leading good fall stands and growth. The fields were planted on time for their respective eco-geographic zones and fertilizer was generally applied before planting, thought the expected prices for the crop lead to less inputs (fertilizer, pesticides) being used than when wheat is worth more. Stripe rust was prevalent throughout the state with economic losses in eastern and central Nebraska and under irrigation. Fungicides were frequently used. Wheat streak mosaic virus was prevalent in western Nebraska. Rain at harvest reduced grain yield and quality.

2. Diseases

A decline in production in 2017 (47 million bushels) compared to 2016 (71 million bushels) was partly due to severe epidemics of wheat streak mosaic especially in western Nebraska where the majority of wheat is produced, and moderate to severe levels of stripe rust throughout the state in fields that were not sprayed.

During the 2017 wheat growing season, the main diseases were wheat streak mosaic and stripe rust. Fusarium head blight (FHB) was minimal in all FHB-prone wheat-growing regions of the state. Both incidence and severity of FHB in individual growers' fields were trace to low and DON levels were minimal or negligible. Leaf rust developed to moderate to severe levels in some fields that were not sprayed, but was not as widespread as stripe rust. Low to moderate levels of Septoria tritici blotch, tan spot, and powdery mildew were present in some fields that were not sprayed.

In spring and summer in 2017, the main disease was stripe rust in central and eastern NE . Fungicides were commonly used in those areas. Occasionally a later application of fungicide was applied to control Fusarium head blight (syn. scab), but generally the later application was not needed. Leaf rust came in later and was found on plant that were resistant to stripe rust and still had green leaves. Low levels of *Septoria tritici* blotch, tan spot, and powdery mildew were present in some unsprayed fields. Moderate to severe levels of bacterial streak and black chaff were present at Mead (southeast Nebraska) in the breeding nursery where susceptible wheat lines were planted. In fungicide treated and untreated trials at Lincoln, the yield loss due to foliar disease was 16% (11.6 bu/a). Wheat streak mosaic virus was more widespread and severe than normal due to a warm fall and various production reasons including not controlling volunteer wheat or planting cover crops in hopes the cover crop might reduce the volunteer weaht. Drs. Stephen Wegulo (plant pathologist), Jeff Bradshaw and Gary Hein (entomologists monitoring insect vectors of disease), and Satyanarayana Tatineni (USDA-ARS virologist) continue to be invaluable in disease identification, survey, and understanding. Little disease was found on winter barley and winter triticale. In 2017, the incidence of cephalosporium stripe, caused by a soilborne pathogen *Cephalosporium gramineum*, was high and it has been increasing in the past three years. The conditions in spring 2017 was conducive for the disease as infection is favored by cool, 45 to 55°F, and moist conditions. It was more severe in wheat fields that followed wheat or other susceptible cereal or grasses such as oat, barley, rye, triticale, and grasses such as downy (cheatgrass) brome. In a yearly survey, Dr Tony Adesemoye observed that the disease was more prevalent in low, wet areas of the field and acid soils and the diagnostic symptoms of yellow stripe occurred more frequently on the lower leaves.

3. **Insects**

Nebraska continues to have small outbreaks of Hessian fly and the diseases vectored by aphids (barley yellow dwarf virus). In 2016, there was a major outbreak of wheat streak mosaic virus (WSMV) and others viruses vectored by mites. The wide scale WSMV epidemic was due to growers not controlling volunteer wheat (e.g. with low wheat prices, they tried to have fewer inputs) and sometimes to the mistaken idea that cover crops might hide volunteer wheat from the mites and WSMV infection. It is believed at harvest that virtually every wheat plant in Nebraska may hae seen a wheat curl mite, so hoping the volunteer wheat plants may have escaped infection was theoretically and in practice wrong. The wheat stem sawfly continues to be pervasive throughout the Nebraska Panhandle.

4. **Small Grains Production**

In 2016-2017 season, 1,120,000 acres of wheat were planted in Nebraska and 1,020,000 were harvested with an average yield of 46 bu/a for a total production of 46,920,000 bu. The crop generally got off got a good start and survived the winter, but in the spring a number of diseases and wheat stem sawfly were abundant. In western and central Nebraska, wheat streak mosaic virus was quite common. Wheat stem sawfly also continued to expand into Nebraska from the west, though fortunately parasites lessened some of the damage. In eastern Nebraska, the rusts (led by stripe rust and then leaf rust were very common). In 2015-2016 season, 1,370,000 acres of wheat were planted in Nebraska and 1,310,000 were harvested with an average yield of 54 bu/a (a record yield/acre) for a total production of 70,740,000 bu. In 2014-2015 season, 1,490,000 acres of wheat were planted in Nebraska and 1,210,000 were harvested with an average yield of 38 bu/a for a total production of 45,980,000 bu. The yield losses due to controllable fungal diseases in eastern Nebraska in 2015, 2016, and 2017 were 44%, 32% and 16%, respectively. Despite continued genetic improvement, the main determinant in wheat production seems to be acres harvested, government programs, and weather (which also affects disease pressure and sprouting). This is an economic reality in understanding wheat yields and productivity in NE. Barley or triticale acreages are not reported in the NASS surveys but the general feeling is that locally produced barley is finding a fit for micromalsters and microbrewers, forage for dairies, and feed for animals. Triticale acreage continues to increase, primarily as an annual forage crop and to a lesser extent as a feed crop.

5. Cultivar Distribution

Nebraska began retaking the variety surveys in 2015, however due to financial constraints did not do one in 2017. From seed sales, Ruth had an excellent year and should be adopted well in western NE. Robidoux, Freeman, and many of the commercially developed lines continue to be popular. The one line that has dropped in sales (and expected acreage) is Settler CL. Newer genetics and newer 2-gene lines have taken much of previous Settler CL acreage. At the last survey, the variety distribution is remarkable in that no variety has over 10% of the acreage. In 2016, SY Wolf (7.4%), Winter Hawk (7.0%) Settler CL (6.9%) were the most widely grown varieties in Nebraska followed by Brawl CL Plus (5.0%), Overland (4.9%), Byrd (4.5%) TAM 111 (4.3%), and Buckskin (4.2%). An additional, 11 varieties were grown on less than 4% of the acreage. 2.4% were blends and 26% of our acreage where grown in varieties having individually less than 1% of the acreage. We expect this level of diversity in our cultivars has continued in 2017. Of the reported varieties, we estimate about 60% of Nebraska wheat acreage grew varieties developed by the collaborative USDA-ARS, University of Nebraska small grains breeding effort. It should be noted that many commercial lines do not report their seed production for proprietary reasons, so without the survey, it is impossible to know how much of those varieties are produced within the state. While no wheat listed below has all of the characteristics of an ideal wheat, the diverse wheat varieties provide the grower an opportunity to choose high yielding, high quality wheat varieties that have resistance or tolerance to the diseases or insects prevalent in his or her region. Variety diversity is useful, as it should reduce genetic vulnerability to specific disease and insect pests.

III. New Cultivars

The project formally released one new wheat line in collaboration with Limagrain (LCS Link and is expected to license a line to a LCS third party) and developed our first approved 2-gene Clearfield line (NHH144913-3, expected release in 2018) and released 7 new triticale lines (NT055421, NT07403, NT09423, NT11406, NT11428, NT12414, and NT12434). NT12434 was licensed to Limagrain and will be marketed as LCS Bar. NT12414 is also under consideration for licensing. PVP certificates have been submitted for NT07403, NT09423, NT11406, NT11428, and NT12434. These five lines are currently grown from the New York to New Mexico. NHH144913-3 seems to be well adapted to Nebraska and regions north of Nebraska. In the 2017 Northern Regional Performance Nursery with the data reported so far, it ranked third in the region. The triticale cultivars were described in detail in last year's report (can be found at: https://agronomy.unl.edu/Baenziger/annualreports/Whtann16V8-BaenzigerAnnualReport2016.pdf) and will not be described again here.

The triticale lines were developed with partial financial support from the Nebraska Agricultural Experiment Station. Partial funding for P.S. Baenziger is from Hatch project NEB-22-328 and the Nebraska Wheat Development, Utilization, and Marketing Board. Cooperative investigations of the Nebraska Agric. Res. Div., Univ. of Nebraska, and USDA-ARS.

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Table 1. Head to head comparisons of NE422T, NT05421, NT07403, NT09423, NT11406, NT11428, NT12414, and NT12434 to NE426GT for forage and grain yield, flowering date, plant height and bacterial streak from trials in Nebraska beginning in 2007 until 2015. Data on grain yield was from trials at up to three rainfed locations (Mead, Lincoln, and Sidney) and for forage yield was from up to two locations (Mead and Sidney) in Nebraska.

Cultivar	Trial Number	Line Forage Yield kg/ha	NE426GT Forage Yield kg/ha	Percent of NE426GT	Significance	Trial Number	Line Grain Yield kg/ha	NE426GT Grain Yield kg/ha	Percent of NE426GT	Significance	Trial Number	Line Flowering Date d after Jan.1	NE426GT Flowering Date d after Jan.1	Percent of NE426GT	Significance	Trial Number	Line Height cm	NE426GT Height cm	Percent of NE426GT	Significance
NE422T	8	9596	9252	104	n.s.‡	14	3280	3931	83.5	**	10	146.5	142.6	103	**	11	147	120	123	**
NT05421	8	9704	9252	105	n.s.	14	4178	3931	106	n.s.	10	141.8	142.6	99.5	n.s.	11	135	120	113	**
NT07403	8	9174	9252	99.2	n.s.	14	4355	3931	111	**	10	138.8	142.6	97.4	**	11	116	120	96.7	*
NT09423	5	9193	9433	97.4	n.s.	12	4414	3854	115	**	8	143	141.9	101	n.s.	10	120	122	98.7	ns
NT11406	5	8377	8950	93.6	*	9	3641	3395	107	n.s.	6	141.6	140.9	101	n.s.	8	121	121	100	ns
NT11428	5	9323	8950	104	n.s.	9	3627	3395	107	n.s.	6	141.7	140.9	101	n.s.	8	135	121	112	**
NT12414	1	8923	9736	91.7	n.s.	2	3462	3168	109	n.s.	1	148.4	148.3	100	n.s.	1	115	124	93	*
NT12434	1	8144	9736	83.7	**	2	2811	3168	91	n.s.	1	148.6	148.3	100	n.s.	1	124	124	100	ns

Cultivar	Trial Number	Line Height cm	NE426GT Height cm	Percent of NE426GT	Significance	Trial Number	Line acreria Streak (0-9)	NE426GT Bacrerial Streak (0-9)	Percent of NE426GT	Significance
NE422T	11	147.3	120.1	123	**	2	2.15	2.2	97.7	n.s.
NT05421	11	135.4	120.1	113	**	2	2.65	2.2	121	n.s.
NT07403	11	116.1	120.1	96.7	*	2	2.65	2.2	121	n.s.
NT09423	10	120.4	121.9	98.7	n.s.	2	1.3	2.2	59.1	n.s.
NT11406	8	120.7	120.7	100	n.s.	2	2.5	2.2	114	n.s.
NT11428	8	134.6	120.7	112	**	2	2.5	2.2	114	n.s.
NT12414	1	115.1	123.7	93	*					
NT12434	1	123.7	123.7	100	n.s.					

‡ n.s.,*, **, not significantly different, significantly different at the P=0.05 and P=0.01 probability level, respectively.

Ruth continued to do well. Below is the data from the State Variety Trial for 2015-2017.

		State	SE	SC	WC	W			
Brand	**Variety**	**Grain Yield (bu/a)**	**Grain Yield (bu/a)**	**Grain Yield (bu/a)**	**Grain Yield (bu/a)**	**Grain Yield (bu/a)**	**Bushel Weight (lb/bu)**	**Grain Protein (%)**	**Plant Height (inches)**
AgriPro Syngenta	SY Wolf		80		62	45	56	13.7	33.4
Husker Genetics	Freeman	60.4	73	48	69	51	55	13.2	35.7
Husker Genetics	Ruth	62.6	71	56	73	52	57	13.2	37.6
Husker Genetics	Overland	55.3	63	49	63	47	57	13.2	38.2
----	Wesley	50.6	58	42	59	43	54	14.0	34.1
----	Scout 66	38.4	43	24	48	39	55	14.4	41.1
----	Turkey	35.3	40	24	43	34	54	14.6	41.3
Husker Genetics	Robidoux				69	51	57	12.7	33.6
Average of all entries			**62**	**40**	**63**	**45**	55	13	36
Difference required for significance at 5%			**11**	**13**	**9**	**5**	2	0	2

IV. FIELD RESEARCH

1. Increase of New Experimental Lines

With the release of new varieties Husker Genetics Brand Ruth, Overland, Camelot, Freeman, Goodstreak, McGill, Panhandle, Robidoux, and Settler CL over the past several years, most advanced current breeding lines are not expected to be released yet. However, a number of lines are targeted for possible release in 2018. Specifically, the following lines are under increase:

Wheat:

- NE12561 (NI04420/NE00403) –Eastern NE wheat*
- NI12702W (N03Y2014/NW03681//NuHills 10005)
- NI13706 (NI02425/HV9W99-558//Robidoux)—Good statewide
- NW13493 (SD98W175-1/NW03666)—Outstanding white wheat, possible for organic production.
- NE10478-1 (NI03418/Camelot)—very early, southern NE wheat, possible co-release**
- Overland Fhb1 (Overland with Fhb1 for scab tolerance)
- NHH144913-3 (SETTLER CL/NE07457//Brawl CL) –two gene Clearfield line, approved by BASF for release***

* Will be released through NuPride Genetics as Siege Wheat.
** Highly likely to be co-released.
*** Will be released through NuPride Genetics

The relevant head-to-head data (each line compared to Ruth) on the lines for the respective nurseries they were grown in are:

	Grain Yield (bu/a)			Test Weight (Lbs/bu)		
	Line	Ruth		Line	Ruth	
Panhandle	49.8	63.0	***	56.6	59.8	***
Freeman	59.6	63.0	**	56.9	59.8	**
NE10478-1	62.9	62.4	n.s.	58.3	59.4	n.s.
NE12561	59.9	63.0	**	60.4	59.8	n.s.
NE13515	62.6	62.4	n.s.	58.4	59.4	n.s.
NE14434	72.1	72.5	n.s.	58.7	60.4	**
NE14696	63.9	72.5	***	58.5	60.4	***
Robidoux	60.7	63.0	n.s.	59.4	59.8	n.s.
NI12702W	59.6	63.0	**	61.0	59.8	*
NI13706	62.3	63.0	n.s.	60.1	59.8	n.s.
NI14729	57.1	62.4	*	57.0	59.4	*
NW13493	62.3	62.4	n.s.	59.3	58.4	n.s.
Overland	54.8	63.0	***	58.9	59.8	n.s.
Wesley	52.4	63.0	***	52.3	59.8	*

	Flowering date			Height			Lodging		
	d after Jan. 1			in			(0-9, 0 is good)		
	Line	Ruth		Line	Ruth		Line	Ruth	
Panhandle	141.7	141.4	n.s.	41.4	37.9	***	5	1	*
Freeman	139.6	141.4	***	35.9	37.9	***	3.5	1	**
NE10478-1	137	139.8	***	36.6	39.1	***	2	1	n.s.
NE12561	139.7	141.4	**	36.1	37.9	***	1	1	n.s.
NE13515	139.4	139.8	n.s.	39.5	39.1	n.s.	1.5	1	n.s.
NE14434	137	137.1	n.s.	39.5	39.6	n.s.	5	1	n.s.
NE14696	140.3	137.1	**	42.1	39.6	***	1.5	1	n.s.
Robidoux	140.4	141.4	n.s.	37.5	37.9	n.s.	2	1	n.s.
NI12702W	142.0	141.4	*	37.3	37.9	*	1	1	n.s.
NI13706	138.7	141.4	***	35.2	37.9	***	3	1	n.s.
NI14729	140.4	139.8	n.s.	39.0	39.1	n.s.	1.5	1	n.s.
NW13493	139.0	139.8	**	38.0	39.1	***	1.5	1	n.s.
Overland	143.1	141.4	**	38.3	37.9	n.s.	2.5	1	n.s.
Wesley	140.7	139.8	n.s.	35.0	37.9	***	1.5	1	n.s.

	Sr	Lr	YR	HF	SBMV	D.Bunt	Acid Soil	
Panhandle	MR	MS	S	S	MR			
Freeman	MR	MS	MR	SEG	R			
NE10478-1	MR	MR	S	MR	R		S	
NE12561	MR	R	MR	MR	R	S	MS	
NE13515	MR	MS	MR	MS	R			
NE14434	MR	MR	MR/MS	S	R	S		
NE14696	MR	MR/MS	MR	S	R			
Robidoux	MR	MS/S	MR	S	R			
NI12702W	R/MR	MR	MR	S	MR	S	R	
NI13706	MR	MR	MR	S	R	MR	R	
NI14729	MR	MS?	R/MR	R	R			
NW13493	R	MR	MR/MS	S	MR	S		GOOD SPROUT TOLERANCE.
Overland	MR	R	S	S	R?	S		
Wesley	R	S	MS/S	S	R			
NHH144913-3	MR	MS	MR	S	R	S		

R = resistant, MR = moderately resistant, MS = moderately susceptible, and S = susceptible

Data from the 2017 Northern Regional Performance Nursery indicating the excellent grain yield of NHH144913-3.

		Grain Yield		Grain Volume Weight		Heading Date		Plant Height	
		Overall NRPN		Mean	Rank	Mean	Rank	Mean	Rank
Entry	**Line**	**mean**	**rank**	**(kg/hl)**		**(DOY)**		**(cm)**	
1	Kharkof	2756	43	75.5	26	157	38	106	44
2	Overland	4170	14	75.9	32	154	27	87	34
3	Wesley	3346	39	73.2	7	153	11	74	4
4	Jagalene	3817	33	77.2	43	153	14	82	17
5	Jerry	3242	40	72.9	5	156	35	92	41
9	**NE13604**	**4227**	**10**	**75.1**	**20**	**155**	**32**	**88**	**37**
11	**NE14434**	**4303**	**6**	**75.4**	**25**	**153**	**12**	**83**	**24**
13	**NE14606**	**4282**	**8**	**74.6**	**15**	**154**	**21**	**81**	**14**
15	**NHH144913-3**	**4296**	**7**	**72.0**	**2**	**153**	**13**	**81**	**15**
16	**PSB13NEDH-7-140**	**4326**	**3**	**76.4**	**36**	**154**	**29**	**86**	**30**
23	AP-16CP010076	4319	5	75.1	21	152	7	74	5
24	AP-16CP010077	4322	4	75.3	23	151	2	72	2
37	SD13W064-7	4372	1	74.3	12	156	33	83	22
39	SD14115-5	4351	2	75.9	31	154	24	80	13
	SAS Mean	3896							
	l.s.d. (alpha = 0.05)	263							

2. Nebraska Variety Testing

Numerous entries were included in some or all of the locations in the Fall Sown Small Grain Variety Tests in 2017. Thirteen dryland locations in Nebraska were harvested for yield data and the data for the top ten lines grown across the state are presented below. Westbred Grainfield (44% better than Scout 66) topped the trial, followed by LCS Link (an LCS_UNL joint release). Ruth continued to do well, as did a number of new experimental lines. As expected, Scout 66 (57.3 bu/a) and Turkey (46.5 bu/a) were the bottom of the trial.

Dryland Entry	Yield bu/a	Dryland Entry	Yield bu/a
WB-Grainfield	82.7	NE12561	79.3
LCS Link	82.6	NI13706	79.3
NW13570	82.4	NE10478-1	79.0
Ruth	82.1	SY Wolf	78.8
NW13493	79.9	Long Branch	77.9

In 2016, the top ten entries for dryland production (12 environments) were:

2015-2016		Southeast	Southcentral	Southwest	West	State	rank
Brand	Variety	Average Yield (bu/a)	Average Yield (bu/a)	Average Yield (bu/a)	Average Yield (bu/a)	Average Yield (bu/a)	
Husker Genetics	Freeman	78	51	89	59	73.1	1
WESTBRED	WB-Grainfield	77	59	87	57	72.2	2
Husker Genetics	NE10589 (Ruth)	72	52	82	59	69.3	3
Limagrain Cereal Seeds	LCH13NEDH-14-69	75	55	81	55	68.7	4
WESTBRED	WB4721	74	56	79	53	67.2	5
Limagrain Cereal Seeds	PSB13NEDH-14-71	73	51	82	51	66.8	6
Syngenta AgriPro	SY Wolf	78	47	77	52	66.4	7
Dyna-Gro	HRX1652	62	40	80	61	65.8	8
-----	NE09517	68	51	77	55	65.3	9
-----	NI10718W	68	33	76	46	60.4	10
----	Wesley	62	36	75	49	59.8	11
Husker Genetics	Overland	59	35	75	51	59.7	12
----	Scout 66	38	14	54	44	43.3	13
----	Turkey	35	13	52	37	39.5	14
Average all entries		65.8	42.4	77.8	51.6	63.1	
Difference required for significance at 5%		16	10	6	6		

In 2015, the top ten entries for dryland production (13 environments) were:

Dryland Entry	Yield bu/a	 Entry	Yield bu/a
Ruth (NE10589)	42.9	Freeman	39.9

NE10478	41.7	LCH13NEDH-5-59	39.9
Overland Ever	41.2	Overland Ever & Gau	39.8
Overland	40.8	NE09521	39.1
Overland Gau	40.6	NI10718W	39.0

Numerous entries were included in some or all of the locations in the Fall Sown Small Grain Variety Tests in 2014. Twelve dryland locations, plus one irrigated location, in Nebraska were harvested for yield data.

3. **<u>Irrigated Wheat Trials:</u>**

In 2017, one irrigated yield trials was harvested (Chase county). Box Butte county trial was lost. Numerous very high yielding lines were identified. The best lines were experimental lines or those recently released indicating strong breeding programs continue to develop excellent new lines. SY Wolf and the newly released LCS Link, Long Branch, and Langin did well, but, though it should be noted that SY Wolf had excellent protein for its high yield.

Brand	Variety	Grain Yield (bu/a)	Moisture (%)	Bushel Weight (lb/bu)	Plant Height (inches)	Grain Protein (%)	Kernel Weight (1000/lb)
WestBred	WB4303	122.8	8.8	63.0	34	12.4	13.3
CROPLAN by WinField	EXP 69-16	116.0	9.1	65.5	34	11.7	12.8
AgriPro Syngenta	SY Wolf	112.6	9.1	65.9	34	12.4	14.3
Limagrain Cereal Seeds	LCS Link	112.3	9.2	64.9	37	11.9	14.5
Dyna-Gro Seeds	Long Branch	110.8	9.0	64.5	36	11.6	14.3
PlainsGold	Langin	110.7	9.0	63.8	32	11.1	14.6
WestBred	Winterhawk	109.0	9.1	66.3	38	11.9	12.8
AgriPro Syngenta	SY Sunrise	107.6	9.0	64.3	33	12.5	13.4
WestBred	WB-Grainfield	107.2	9.1	65.2	33	11.7	14.2
CROPLAN by WinField	EXP 26-16	106.9	9.2	67.1	38	12.0	12.5
-----	NI13706	105.3	9.1	66.6	33	13.3	14.3
----	Wesley	102.9	9.0	64.9	35	12.4	14.0
Limagrain Cereal Seeds	LCS Chrome	98.6	8.9	63.6	38	14.3	17.2
Westbred	Aspen	98.3	9.1	64.4	33	13.0	14.2
Husker Genetics	Robidoux	97.7	9.1	65.3	36	11.7	14.2
WestBred	WB4458	97.7	8.8	65.3	36	14.5	13.3
AgriPro Syngenta	SY Flint	97.6	9.2	64.7	35	12.8	13.8
----	Mace	97.2	8.9	64.0	36	12.6	15.8
-----	NI10718W	96.1	9.0	63.5	36	12.5	13.8
-----	Ruth	93.2	9.2	66.6	37	12.6	13.7
PlainsGold	Avery	91.4	8.7	61.7	30	10.8	14.0
CRFW	Cowboy	89.6	9.0	64.6	36	12.1	14.3
Limagrain Cereal Seeds	LCS Mint	87.3	9.3	66.5	37	13.7	13.3
Limagrain Cereal Seeds	LCH14-77	86.2	9.1	64.5	37	11.7	14.4
-----	N11MD2166W	85.8	8.9	65.3	37	11.4	15.0
-----	NE12561	85.2	9.1	65.7	36	12.5	13.9
-----	NI12702W	84.4	9.8	67.4	37	12.3	13.3
PlainsGold	Snowmass	80.0	9.2	65.9	32	11.4	13.2
WestBred	WB-Cedar	79.0	9.0	64.8	32	13.1	13.0
-----	N13MD2589W	72.7	9.3	68.1	40	15.2	15.0
Average of all entries		**98.1**	**9.1**	**65.1**	**35**	**12.4**	**14.0**
Difference required for significance at 5%		**15.1**	**0.4**	**3.7**	**4**	**NS**	**1.4**

In 2016, two irrigated yield trials were harvested (Chase and Box Butte counties).

Brand	**Variety**	**Average Yield (bu/ac)**	**Box Butte Yield (bu/ac)**	**Chase Yield (bu/a)**	**Bushel Weight (lb/bu)**	**Height (in)**	**Kernel Weight (000/lb)**	**Grain Protein (%)**
WESTBRED	WB-Grainfield	94	94	93	56	37	16.8	15.0
PlainsGold	Antero	94	99	89	57	34	14.0	13.3
WESTBRED	WB4303	94	97	90	54	35	16.3	15.4
PlainsGold	Brawl Cl Plus	92	79	105	58	35	14.1	15.4
Syngenta AgriPro	SY Wolf	92	98	85	55	36	14.9	14.8
WESTBRED	Winterhawk	91	93	89	56	37	15.8	14.8
Limagrain Cereal Seeds	LCH13NEDH-14-69	91	90	91	57	35	14.9	14.6
PlainsGold	Byrd	90	90	90	56	35	16.4	14.4
WESTBRED	WB4458	90	77	102	57	36	14.0	15.0
Syngenta AgriPro	SY Sunrise	90	85	95	58	35	14.4	14.4
Average of all entries		**83**	**85**	**81**	**56**	**36**	**15.5**	**14.8**
Difference required for significance at 5%		**18**	**20**	**12**	**3**	**2**	**2.1**	**1.1**

In 2015, both irrigated sites were lost to hail or other inclement weather. Hence no new data are reported. In 2014, harvesting only occurred at the Hemingford site.

The top ten lines in 2014 were:

Entry	Yield	Entry	Yield
	bu/a		bu/a
WB-Grainfield	126.7	Brawl Cl Plus	119.5
WB-Cedar	125.3	NE10478	119.4
Denali	123.7	Wesley	119.3
WB4458	121.9	NX04Y2107W	118.8
Byrd	120.3	Antero	117.7

The irrigated data this year continues to show the benefits of having a dedicated irrigated wheat development nursery to select lines that have excellent performance (e.g. NI13706).

In 2017, due to financial restraints we had to drop the experimental line irrigated nursery. However, we were able to keep a dryland nursery that included lines that may have potential under irrigation. The selectd lines tended to have better straw strength and shorter plant height. The goal of this nursery is to identify higher yielding lines under irrigation and under higher rainfall conditions, which periodically occur in Nebraska.

	Lincoln	**N. Platte**	**Alliance**	**Rainfed A**	**RankD**	**Hdate**	**Height**	**TestWT**	**Lodging**
	Yield	**Yield**	**Yield**	**Yield**		**Julian**			
Enry	**Bu/a**	**Bu/a**	**Bu/a**	**Bu/a**		**d**	**In**	**lbs/bu**	**0-9**
Antelope	54.7	50.2	60.8	55.23	**29**	136.3	27.0	57.7	5.4
Robidoux	70.4	57.5	74.3	67.40	**5**	136.7	28.0	56.4	4.7
NI10718W	53.7	57.2	51.0	53.97	**32**	136.0	27.2	54.2	5.3
WESLEY	51.0	57.0	59.5	55.83	**26**	136.7	26.5	55.3	3.6
NW07534	57.9	60.3	59.2	59.13	**17**	136.0	26.1	55.8	4.7
Settler CL	55.3	51.8	49.6	52.23	**38**	135.3	26.8	55.2	4.3
NI13717	69.7	57.2	62.8	63.23	**9**	135.0	27.8	58.9	5.0
NI14722	65.5	60.3	64.3	63.37	**8**	135.0	25.7	58.6	6.7
WB CEDAR	60.8	49.6	56.2	55.53	**28**	135.0	24.8	55.6	5.0
NI14729	57.1	65.3	70.9	64.43	**7**	136.7	28.4	56	6.3
NI14732	55.5	50.9	61.4	55.93	**25**	135.0	26.0	56.1	4.0
NI14733	53.9	54.3	60.2	56.13	**23**	135.7	28.9	55.7	5.7
SY Wolf	62.2	41.7	45.6	49.83	**40**	135.7	27.1	56.3	4.0
NI15705	61.9	43.1	52.9	52.63	**37**	136.3	26.0	55.2	3.0
NI15711	47.0	59.9	54.1	53.67	**35**	135.0	25.8	55.2	6.3
NI15713	58.3	48.4	60.5	55.73	**27**	136.3	26.6	55.2	5.0
NE14421	75.3	67.8	63.5	68.87	**2**	136.3	27.2	57.6	4.7
NE14531	56.3	60.4	58.4	58.37	**18**	135.7	28.8	54.3	5.3
NE14538	80.4	67.3	57.0	68.23	**3**	136.3	28.0	57.9	5.7
NE14606	65.5	65.3	65.3	65.37	**6**	137.3	27.9	53.6	5.0
NE10478-1	75.8	58.3	76.0	70.03	**1**	135.0	26.6	58.3	5.7
NE15420	65.8	42.4	60.0	56.07	**24**	135.7	25.9	56.4	3.0
NI17401	72.2	52.8	48.8	57.93	**19**	135.7	28.0	55	5.3
NI17402	68.7	53.8	50.6	57.70	**20**	135.7	26.9	52.7	2.7
NI17403	62.2	46.0	54.6	54.27	**31**	136.7	28.4	54.8	4.0
NI17404	55.5	47.9	56.8	53.40	**36**	135.3	29.4	56.3	4.0
NI17405	62.4	47.7	52.9	54.33	**30**	136.3	28.3	53.4	4.3
NI17406	68.0	46.8	64.1	59.63	**16**	135.3	27.1	54.5	5.0
NI17407	55.6	49.4	56.2	53.73	**33**	137.3	26.4	56.1	4.3
NI17408	79.2	51.3	51.8	60.77	**13**	135.0	26.1	56.3	5.0
NI17409	72.6	58.3	58.0	62.97	**10**	135.0	27.2	57.7	4.0
NI17410	76.8	53.1	58.9	62.93	**11**	135.0	27.3	57.8	4.0
NI17411	54.7	51.4	48.7	51.60	**39**	135.0	27.8	56.9	3.7
NI17412	69.6	46.7	56.8	57.70	**20**	135.0	27.0	58.2	6.0
NI17413	67.3	46.6	47.3	53.73	**33**	135.0	27.1	54.9	3.3
NI17414	73.5	57.1	55.9	62.17	**12**	135.3	27.7	56.3	5.0
NI17415	81.0	51.4	49.9	60.77	**13**	135.0	27.5	55	5.3
NI17416	72.9	44.1	53.1	56.70	**22**	135.3	27.1	55.6	5.7
NI17417	72.1	54.6	76.1	67.60	**4**	135.0	27.1	56.3	5.0
NI17418	63.2	50.5	65.6	59.77	**15**	139.7	29.2	54.9	5.0
Average	**64.54**	**53.39**	**58.24**			**135.79**		**55.96**	**4.75**
LSD	**11.37**	**11.23**	**13.91**			**0.76**		**3.11**	**1.42**
CV	**9.01**	**10.77**	**12.22**			**0.34**		**3.4**	**18.26**

The data for 2016 were:

	Lincoln	N. Platte	Alliance	Rainfed Avg.	RankD	Alliance	RankI		Rank					
Name	Yield	Yield	Yield	Yield		IR Yield		Avg.All		Hdate	Height	TestWt	Moist	Protein
	bu/a	bu/a	bu/a	bu/a		bu/a		bu/a		Jullian				
Antelope	**67.0**	**54.0**	**53.2**	**58.1**	35	97.8	21	68.0	36	133.0	35.1	61.1	10.1	15.6
Robidoux	**82.5**	**62.1**	**66.3**	**70.3**	9	106.4	11	79.3	7	134.0	35.9	61.7	10.6	15.3
NI10718W	**70.4**	**82.5**	**52.4**	**68.4**	11	103.1	16	77.1	10	133.7	34.9	59.6	9.9	15.8
WESLEY	**74.1**	**86.1**	**53.4**	**71.2**	6	93.5	30	76.8	11	133.7	33.3	58.9	10.1	16.5
NW07534	**78.6**	**65.6**	**63.3**	**69.2**	10	103.9	15	77.9	9	133.3	34.0	60.4	10.3	16.2
NI13703	**66.2**	**62.9**	**60.9**	**63.3**	20	94.1	27	71.0	25	132.7	34.8	60.9	10.3	16.8
Settler CL	**64.0**	**73.8**	**46.4**	**61.4**	29	90.0	36	68.6	34	133.7	34.1	60.4	9.8	15.5
NI13717	**71.2**	**69.9**	**49.6**	**63.6**	19	94.3	26	71.3	23	133.0	35.2	60.5	10.2	17.2
NI14722	**67.4**	**68.7**	**62.3**	**66.1**	15	104.2	14	75.7	12	133.0	33.1	62.1	10.9	16.1
WB CEDAR	**64.3**	**67.8**	**53.7**	**61.9**	25	90.6	35	69.1	32	133.0	33.1	60.7	10.3	17.5
NI14727	**64.0**	**61.8**	**44.4**	**56.7**	38	85.1	39	63.8	40	134.8	36.6	60.9	10.2	16.2
NI14729	**81.9**	**98.1**	**63.1**	**81.0**	1	110.6	4	88.4	1	135.3	36.9	60.5	10.6	15.2
NI14732	**71.9**	**67.2**	**47.4**	**62.2**	24	94.0	28	70.1	27	133.0	35.0	60.0	10.4	16.0
NI14733	**72.0**	**58.9**	**52.6**	**61.2**	31	85.3	38	67.2	38	133.4	37.6	58.5	11.0	15.2
NI14735	**58.9**	**75.3**	**54.3**	**62.8**	21	96.1	25	71.2	24	133.1	34.6	59.7	10.3	15.4
SY Wolf	**85.5**	**59.4**	**51.9**	**65.6**	17	104.7	13	75.4	13	133.4	34.3	61.1	10.7	16.2
NE07531	**80.6**	**61.7**	**59.6**	**67.3**	14	93.7	29	73.9	16	133.0	35.6	60.7	10.3	16.3
NI15701	**75.8**	**55.0**	**57.5**	**62.8**	22	91.0	34	69.8	28	133.0	34.8	60.2	10.3	16.2
NE15434	**70.7**	**45.5**	**56.0**	**57.4**	37	96.8	24	67.3	37	135.3	34.5	62.1	10.9	15.9
NE15420	**78.0**	**46.9**	**61.7**	**62.2**	23	111.4	3	74.5	14	133.3	32.3	60.5	10.3	16.1
NI15704	**75.3**	**45.8**	**52.7**	**57.9**	36	101.7	18	68.9	33	133.0	32.9	60.7	10.4	15.9
NI15705	**70.3**	**56.2**	**54.5**	**60.3**	32	108.7	6	72.4	20	133.0	32.1	59.7	11.3	16.1
NW15677	**70.4**	**37.5**	**57.0**	**55.0**	40	93.2	32	64.5	39	133.7	33.3	61.4	10.3	16.5
NI15710	**75.4**	**56.4**	**52.6**	**61.5**	28	97.6	22	70.5	26	134.7	33.6	61.3	10.7	15.9
NI15711	**75.2**	**53.6**	**55.7**	**61.5**	27	107.2	10	72.9	18	133.0	33.2	59.4	10.5	16.3
NI15713	**78.3**	**57.8**	**66.9**	**67.7**	13	114.6	1	79.4	6	134.3	34.7	60.0	10.5	16.2
NE14421	**74.3**	**85.4**	**66.8**	**75.5**	2	108.5	7	83.8	2	134.7	35.0	61.1	10.8	15.8
NE14448	**73.0**	**59.6**	**51.1**	**61.2**	30	105.5	12	72.3	21	133.0	37.7	60.8	10.3	16.3
NE14494	**82.9**	**60.1**	**52.5**	**65.2**	18	97.9	20	73.4	17	134.7	36.0	61.8	10.9	15.7
NE14531	**86.9**	**77.1**	**50.6**	**71.5**	5	112.6	2	81.8	4	133.1	37.3	60.7	9.9	16.5
NE14538	**83.8**	**75.0**	**61.9**	**73.6**	3	108.4	8	82.3	3	133.3	35.9	60.8	10.3	15.9
NE14606	**73.5**	**81.9**	**60.5**	**72.0**	4	109.7	5	81.4	5	134.3	36.0	60.7	10.4	15.7
NE14632	**73.0**	**66.6**	**57.6**	**65.7**	16	88.6	37	71.5	22	135.6	40.5	59.2	10.0	16.2
NE14656	**95.3**	**29.7**	**55.2**	**60.1**	33	98.5	19	69.7	29	133.7	33.9	60.7	10.8	15.3
NE14674	**54.4**	**55.6**	**59.5**	**56.5**	39	108.2	9	69.4	30	135.6	36.7	63.3	11.1	17.0
NE14686	**72.0**	**57.1**	**55.7**	**61.6**	26	91.8	33	69.2	31	135.3	37.1	59.9	11.0	16.9
NE14696	**69.1**	**55.2**	**50.7**	**58.3**	34	97.1	23	68.0	35	134.7	36.9	61.2	11.4	16.8
NE14700	**72.1**	**84.7**	**54.4**	**70.4**	8	79.5	40	72.7	19	135.0	37.6	58.2	10.0	15.4
Ruth	**88.2**	**54.5**	**61.4**	**68.0**	12	93.4	31	74.4	15	133.7	36.5	61.9	10.2	15.6
NE10478-1	**76.3**	**69.7**	**65.3**	**70.4**	7	102.3	17	78.4	8	133.0	34.4	62.0	10.5	17.6
Average	**74.1**	**63.6**	**56.3**			**99.3**		**73.3**		**133.8**	**35.2**	**60.6**	**10.5**	**16.1**
CV	**9.9**	**19.4**	**10.1**			**7.9**								
LSD	**14.3**	**24.1**	**9.3**			**12.9**								

Some lines such NI14729and NE14421 seem to do remarkably well under rainfed and irrigated conditions. A successful irrigated wheat will need to perform under less than optimal as well as optimal conditions to provide the grower with the stable production they should expect.

The data for 2015 are:

Name	Lincoln	North Platte	Alliance	Average	RANK	Winter Surv.	Anthesis Date	Height
	Bu/a	Bu/a	Bu/a	Bu/a		%	D after Jan.1	(in)
Antelope	59.5	33.3	31.8	41.53	**21**	98.6	140.8	33.2

Robidoux	45.8	41.0	38.8	41.87	**19**	79.2	141.3	35.8
NI08707	63.6	39.9	45.9	49.80	**2**	97.4	145.4	31.4
NI10718W	56.0	56.0	35.5	49.17	**3**	97.3	140.6	34.4
WESLEY	55.1	47.8	38.9	47.27	**5**	101.3	140.7	33.9
NW07534	53.7	42.7	34.7	43.70	**10**	99.6	141.9	33.4
NI12713W	48.5	36.1	29.4	38.00	**24**	98.6	140.1	35.5
NI13703	49.9	25.7	28.3	34.63	**32**	92.1	140.1	32.6
NI13704	52.9	24.6	26.0	34.50	**33**	99.8	140.1	31.8
Settler CL	62.8	34.4	33.9	43.70	**11**	100.1	140.9	34.3
NI13717	48.1	27.6	28.6	34.77	**30**	98.3	142.8	31.8
NI14719	37.3	20.6	12.2	23.37	**39**	95.7	141.4	31.7
NI14721	48.3	26.7	32.4	35.80	**27**	100.2	142.7	34.1
NI14722	50.0	36.3	40.3	42.20	**17**	100.7	139.1	30.2
WB CEDAR	59.2	37.9	30.0	42.37	**16**	100.6	138.6	28.0
NI14727	53.4	41.0	35.1	43.17	**15**	100.2	141.6	37.5
NI14729	65.2	63.4	44.9	57.83	**1**	100.4	141.9	36.6
NI14732	42.7	31.3	26.7	33.57	**34**	92.4	140.9	31.5
NI14733	32.2	32.4	31.3	31.97	**35**	91.4	144.5	36.5
NI14735	52.9	43.2	46.3	47.47	**4**	98.7	142.0	35.4
SY Wolf	49.3	32.3	24.1	35.23	**29**	87.4	142.5	30.9
NE07531	63.3	33.2	33.6	43.37	**13**	95	140.3	35.3
NI15701	46.6	35.1	44.5	42.07	**18**	85.7	143.9	34.4
NE15434	43.0	55.2	43.1	47.10	**8**	93.6	144.7	35.1
NI15702	30.6	26.5	10.5	22.53	**40**	58	142.7	33.4
NI15703	45.4	22.1	21.0	29.50	**36**	95.8	149.3	35.5
NE15420	52.7	39.4	37.7	43.27	**14**	85.9	143.7	30.2
NI15704	48.2	31.6	45.2	41.67	**20**	85.8	143.4	29.7
NI15705	41.1	38.0	38.0	39.03	**23**	82.9	145.6	29.8
NI15706	36.6	40.2	30.0	35.60	**28**	77.4	141.4	32.5
NE15484	56.1	33.8	22.5	37.47	**25**	92.8	144.1	38.7
NI15707	53.8	19.3	31.1	34.73	**31**	90.7	138.8	30.3
NI15708	38.2	20.2	22.8	27.07	**38**	79	142.4	29.4
NI15709	52.3	46.0	32.4	43.57	**12**	89.2	145.1	33.1
NW15677	57.1	48.4	36.2	47.23	**6**	93	142.6	31.8
NI15710	53.7	47.3	38.8	46.60	**9**	94	141.3	35.1
NI15711	61.6	38.1	23.4	41.03	**22**	99.3	139.4	30.6
NI15712	54.2	25.3	30.9	36.80	**26**	96.2	141.1	30.2
NE15558	32.9	36.4	16.2	28.50	**37**	90.5	141.2	32.0
NI15713	58.9	42.5	40.3	47.2Stehpen 3	**6**	94.1	142.4	35.3
Alpha level	0.05	0.05	0.05			0.05		
CV	13.2	21.6	13.9			9.8		
GRAND MEAN	50.32	36.32	32.31			92.71	142.08	33.04
Heritability	0.59323	0.56512	0.77265			0.36415		
LSD	10.9	12.8	9.1			14.8		

The three-year averages for the lines tested in all three years (2015-2017) are below. The importance of the sustained effort in irrigation is that it provides us with a window into the highest yielding environments, something that rainfed environments rarely do. The mean yield of the lines in the 2014-2016 irrigated environments (104 bu/a) is roughly twice that of the 2014-2016 rainfed environments (55 bu/a) for the same years. As can be seen in the table, Robidoux (NI04421) continues to be an excellent rainfed wheat with broad adaptation. Settler CL continues to be one of our most broadly adapted wheats from rainfed to irrigated. Additional wheat experimental lines perform well extremely well in either rainfed or irrigated production systems. The question will be, "Can a wheat with excellent irrigated production capabilities have a sufficient market to warrant its release for irrigated production environments alone?"

		Lincoln	N. Platte	Alliance	Rainfed AVG	RankD
		Yield	Yield	Yield	Yield	
Year		Bu/a	Bu/a	Bu/a	Bu/a	
2015-17	NI14729	69.5	81.7	67.0	72.73	1
2015-17	NE14421	74.8	76.6	65.2	72.18	2
2015-17	NE14538	82.1	71.2	59.5	70.90	3
2015-17	NE10478-1	76.1	64.0	70.7	70.23	4
2015-17	NI04421	76.5	59.8	70.3	68.85	5
2015-17	NE14606	69.5	73.6	62.9	68.67	6
2015-17	NE14531	71.6	68.8	54.5	64.95	7
2015-17	NI14722	66.5	64.5	63.3	64.75	8
2015-17	NW07534	68.3	63.0	61.3	64.15	9
2015-17	WESLEY	62.6	71.6	56.5	63.52	10
2015-17	NI13717	70.5	63.6	56.2	63.40	11
2015-17	NI15713	68.3	53.1	63.7	61.70	12
2015-17	NI10718W	62.1	69.9	51.7	61.20	13
2015-17	NE15420	71.9	44.7	60.9	59.13	14
2015-17	NI14732	63.7	59.1	54.4	59.05	15
2015-17	WB CEDAR	62.6	58.7	55.0	58.73	16
2015-17	NI14733	63.0	56.6	56.4	58.65	17
2015-17	SY Wolf	73.9	50.6	48.8	57.72	18
2015-17	NI15711	61.1	56.8	54.9	57.58	19
2015-17	Settler CL	59.7	62.8	48.0	56.82	20
2015-17	Antelope	60.9	52.1	57.0	56.65	21
2015-17	NI15705	66.1	49.7	53.7	56.48	22
2015-17	Average	68.2	62.4	58.7	63.09	

4. Nebraska Intrastate Nursery:

In 2017, Nebraska Intrastate Nursery (NIN) was planted at eight locations in Nebraska: Lincoln, Mead, Clay Center, McCook (added due to generous support from Ardent Mills), North Platte, Grant (added due to a generous gift from Marvin Stumpf), Sidney, and Hemingford. In addition, two replications at Lincoln were sprayed three times with fungicides to control disease, while two replications were not treated which allowed a comparison of diseased vs. largely disease free genotypes. The sites at Grant, McCook, and Alliance were also sprayed with a single application of fungicide. At Lincoln, the untreated plots yielded 16% less thant he fungicide treated plots (an average of 11.6 bu/a) in a year when disease was relatively minor compared to previous years. The lowest yielding site was Grant mainly due to drought. McCook had excellent yields. The 2017 data are:

	Mead	Linc. IM	Lincoln	C Center	N. Platte	McCook	Grant	Sidney	Alliance	**Average**	Rank
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	**Yield**	
Name	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	**Bu/a**	
CHEYENNE	44.8	31.6	26.7	52.3	53.9	60.7	33.0	49.4	44.8	44.13	60
GOODSTREAK	59.8	65.0	44.1	55.1	48.8	71.8	36.9	55.3	59.8	55.18	58
Panhandle	53.4	66.3	42.4	56.2	50.2	83.4	49.7	64.1	53.4	57.68	57
Freeman	71.7	70.9	68.5	66.2	69.5	97.7	54.7	66.7	71.7	70.84	11
NE12439-H	62.7	83.4	69.4	69.6	68.7	91.0	45.6	60.4	62.7	68.17	23
NE12561	62.3	82.2	80.1	75.9	60.8	88.0	55.4	59.8	62.3	69.64	18
NE12589	74.2	71.0	55.5	70.4	63.0	95.9	47.1	58.5	74.2	67.76	26
NE13434	64.5	80.8	76.5	72.6	58.8	88.3	41.3	58.3	64.5	67.29	29
Ruth	68.6	91.1	80.5	77.6	62.8	111.3	49.9	62.5	68.6	74.77	2
NE10478-1	67.0	89.5	75.3	69.1	64.5	97.0	55.6	73.0	67.0	73.11	4
NE13515	59.6	74.0	72.1	71.3	63.8	98.7	58.0	60.4	59.6	68.61	21
NE13597	47.5	69.5	53.6	66.0	67.4	89.4	48.9	59.4	47.5	61.02	50
NE13604	67.9	66.6	45.5	68.4	64.4	101.3	50.8	64.9	67.9	66.41	34
NE14434	70.3	91.3	84.9	66.0	75.8	97.7	37.3	63.8	70.3	73.04	5
NE14448	56.0	59.6	56.5	69.7	62.9	75.2	45.1	54.7	56.0	59.52	53
NE14531	52.9	73.7	64.9	66.7	71.2	87.3	49.3	59.6	52.9	64.28	40
NE14538	51.7	88.3	69.1	66.5	78.5	92.1	47.0	52.9	51.7	66.42	33
NE14606	59.6	71.8	65.9	69.9	70.4	95.0	51.4	63.4	59.6	67.44	27
NE14663	58.6	68.7	57.7	66.7	66.8	90.6	48.8	58.5	58.6	63.89	42
NE14494	69.7	77.1	64.0	75.2	66.0	103.8	44.8	60.3	69.7	70.07	15
NE14691	57.2	86.8	72.0	79.3	70.4	88.3	51.7	55.2	57.2	68.68	19
NE14696	68.3	67.7	53.7	68.2	62.1	102.7	47.3	59.9	68.3	66.47	32
Robidoux	74.3	89.9	64.7	71.8	67.3	95.0	54.1	64.7	74.3	72.90	6
NI12702W	62.4	79.6	64.7	70.2	69.8	99.0	51.8	57.7	62.4	68.62	20
NI13706	73.3	80.0	86.2	67.0	76.7	82.8	60.4	58.6	73.3	73.14	3
NI14729	69.2	47.4	55.4	62.4	69.2	99.5	59.7	66.5	69.2	66.50	31
NI15713	66.6	65.5	52.6	62.0	60.0	91.9	46.7	64.7	66.6	64.07	41
NW13493	67.0	63.1	74.5	71.0	77.2	102.8	56.3	68.2	67.0	71.90	9
NW13570	61.3	80.3	60.1	77.6	69.6	98.7	59.2	66.5	61.3	70.51	12
OVERLAND	63.7	70.5	51.2	69.0	55.6	90.5	43.2	60.5	63.7	63.10	43
PSB13NEDH-14-83W	77.5	86.5	58.0	63.9	75.8	97.3	54.1	64.6	77.5	72.80	7
SCOUT66	53.8	46.2	37.6	50.1	50.7	63.5	40.3	50.2	53.8	49.58	59
Settler CL	44.9	76.5	52.9	60.4	66.2	87.3	50.2	64.6	44.9	60.88	52
WESLEY	55.7	66.9	60.8	59.2	69.1	81.2	50.8	57.2	55.7	61.84	48
NE15405	64.2	64.7	75.7	67.9	72.2	83.5	40.1	61.8	64.2	66.03	37
NE15406	77.2	75.8	67.9	69.7	64.9	97.0	58.7	62.1	77.2	72.28	8
NE15410	71.1	79.5	57.0	67.8	67.3	103.9	52.4	68.1	71.1	70.91	10
NE15417	62.2	68.9	62.7	65.9	66.7	87.3	39.3	50.0	62.2	62.80	45
NE15434	61.0	68.1	52.6	64.9	69.1	98.5	49.8	59.5	61.0	64.94	39
NE15440	63.2	76.9	69.8	62.9	68.6	83.0	52.1	60.4	63.2	66.68	30
NE15445	55.2	82.4	73.9	66.7	75.4	91.5	54.2	56.0	55.2	67.83	25
NE15468	62.9	75.5	62.9	70.8	64.8	97.0	50.6	65.7	62.9	68.12	24
NE15475	51.7	50.9	50.3	63.6	68.9	89.1	49.9	54.7	51.7	58.98	55
NE15545	57.4	72.6	58.7	66.0	55.5	88.9	36.0	56.0	57.4	60.94	51
NE15571	64.7	72.4	65.3	68.6	80.2	96.0	53.7	63.8	64.7	69.93	16
NE15595	63.9	79.7	58.9	65.6	52.6	103.2	52.9	65.5	63.9	67.36	28
NE15605	58.3	81.7	60.8	73.2	76.0	88.0	45.1	55.5	58.3	66.32	35
NE15624	78.8	91.6	82.0	76.0	67.1	97.4	56.4	67.7	78.8	77.31	1
NE15689	58.9	75.5	68.2	70.5	58.2	91.3	45.1	60.9	58.9	65.28	38
Misplant	64.0	85.1	58.9	62.2	67.0	101.3	46.0	65.9	64.0	68.27	22
NH144922-1	58.3	68.1	50.2	54.1	64.8	90.1	47.6	59.6	58.3	61.23	49
NW15404	66.7	79.4	72.2	73.9	67.8	95.2	53.0	58.1	66.7	70.33	13
NW15443	62.2	86.9	69.9	69.1	71.4	101.1	47.8	56.9	62.2	69.72	17
NW15564	55.2	80.9	61.4	71.2	69.3	93.8	53.9	54.8	55.2	66.19	36
NW15573	74.8	70.0	65.6	72.0	67.5	97.2	48.8	62.0	74.8	70.30	14
NW15677	62.8	69.7	67.7	62.3	57.7	80.4	46.7	56.1	62.8	62.91	44
NI14735	59.7	66.6	46.9	63.0	58.5	88.9	53.3	60.1	59.7	61.86	47
NE15420	49.2	72.5	53.3	66.3	47.8	69.1	49.6	63.4	49.2	57.82	56
NE09517_6	55.7	66.3	42.3	68.6	58.0	94.9	36.5	57.2	55.7	59.47	54
NE16422	47.2	74.5	67.9	58.7	59.2	83.5	58.0	61.7	47.2	61.99	46
GRAND MEAN	**62.07**	**73.59**	**62**	**67.08**	**65.41**	**91.47**	**49.24**	**60.47**	**62.07**		
LSD	14.92	18.13	14.18	6.58	9.98	16.66	9.98	7.12	14.92		
CV	12.49	12.11	11.26	6.04	7.53	7.49	8.34	7.25	12.49		

In 2016 Nebraska Intrastate Nursery (NIN) advance wheat, fifty-seven wheat cultivars or lines were analyzed for kernels characteristics, milling performance, ash and protein contents, dough rheological and bread-making properties.

There were significant differences in kernels characteristics among these cultivars. The kernels hardness indexes were 63.7±7.4. 75% samples had high hardness between 60.0 and 80.0, including SettlerCL and Cheyenne checks, and the rest of samples had low hardness < 60, including Scouts66, Wesley and Goodstreak checks. Eight samples were classified as MIXED and the remaining samples were HARD. The kernels diameters and weights were 2.6±0.1 mm and 30.9±2.1 mg, respectively. Except of NE14531 kernels had small diameters (2.3 mm), and the rest of samples had large kernels diameters (≥ 2.4 mm). Most (68%) samples had big kernels weights (≥ 30.0 mg) including all checks. There were only 18%, 53% and 11% samples had small kernels hardness ($\sigma < 17$), diameters ($\sigma < 0.4$), and weights ($\sigma < 8$) variances. The wheat kernels were diverse in hardness, size and weight.

The kernels hardness indexes were correlated significantly positively with bran cleaning and milling performances, and negatively with bran yields. The flour yields were correlated significantly positively with bran cleaning and milling performances, and negatively with brain and short yields.

There were significant differences in ash and protein contents respectively among these cultivars' flour. The ash contents of white flour (WF) at 14% mb were 0.39±0.07%. Except NE12561 got very high ash content (0.88%), the rest of samples had low ash contents (< 0.50%). The protein contents of whole wheat (WW) at 12% mb were 12.8±1.0% and 81% samples had high protein contents of WW (≥ 12.0%) including all checks. The protein contents of WF at 14% mb were 11.3±0.7%. Except NE14663 got small protein content (9.8%), and the rest of samples got high protein contents of WF (≥ 10.0%). After milling, protein contents were lost 1.2±0.9%. Some samples got high protein losses (> 2.0%). The protein contents of WF were significantly correlated with those of WW.

There were significantly differences in dough rheology among these cultivars' flour. The flour water absorptions (abs) at 14% mb were 62.7±1.3%. Except NE14663 got small water abs (60.0%), and the rest of samples had high water abs (≥ 61.0%). The peak times (PT) were 6.3±2.0 min. 46% samples got good dough extensibility (3.0-6.0 min) including Scouts66, Overland and Goodstreak, and the rest of samples got large dough extensibility (≥ 6.0 min) including Wesley, SettlerCL, and Cheyenne . The peak torques (PQ) were 43.4±2.6 %TQ, and only 30% samples got high dough strengths (≥ 45.0 %TQ) including Scouts66, Wesley, and Goodstreak . The total areas (TA) were 105±13 %TQ·min and tolerance rates (TR) were 3.9±0.7. Both TR and TA were strongly significantly correlated each other. About 50-60% samples got good dough resistance for mixing (TR ≥ 4.0 or TA ≥ 100 %TQ·min), but most (91%) samples got fair or better than fair mixing tolerance including all checks.

There were significant differences in bread-making performances among these cultivars' flour. The baking water abs at 14% mb were 62.7±0.9%. A few samples (Overland, NE14663, and NE09517-6) got small water abs (61.0%), and the rest of samples got high water abs (≥ 62.0%). The mixing times (MT) were 6.9±2.0 min. 35% samples got normal MT between 3.0 and 6.0 min including Scouts66, Overland, and Goodstreak, and the rest of samples got long MT (≥ 6.0 min) including Wesley, SettlerCL and Cheynenne. The dough handling rates were 4.0±0.2. The weight losses were 17.9±1.1%. The slice areas were 107±5 cm^2. The loaf volumes and specific volumes (SV) were 898±56 cc and 6.4±0.4 cc/g, respectively. 84% samples got volumes ≥ 850 cc or SV ≥ 6.0 cc/g including Scouts66, Overland, SettlerCL, Cheynenne and Goostreak. After stored overnight, the bread crumb firmness was 2824±462 Pa. The crumb brightness and non-uniformity was 151±5 and 5.3±4.0, respectively. The cell numbers, diameters and elongation were 6471±266, 2.0±0.1 mm, and 1.50±0.02, respectively. Most samples had good crumb texture and structures. The overall bread rates were 4.3±0.4. All samples including checks got fair or better than fair bread quality, and 81% samples got good or better bread quality including Scouts66, Overland, Cheyenne, and Goodstreak. It is strange that Wesley got less bread quality than

Overland in this year.

The wheat flour protein contents significantly affected on dough rheological properties, which impacted on final bread quality. In detail, the WF protein contents were correlated significantly positively with water abs, dough strengths, weight losses, loaf volumes and areas, cells diameters, and crumb softness as well bread rates.

The 2016 NIN data are:

Name	Mead	Mead.IM	Linc.	Linc.IM	C.Center	N.Platte	McCook	Grant	Sidney	Alliance	Kansas	NE. Ave.	NE Rank	Ave	Rank	Test	Hdate	Height	Moist
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield		Yield		weight	Julian		
	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a		bu/a		lbs/bu	After Jan.1	In	%
	yb_m16	yb_mim16	yb_l16	yb_lim16	yb_cc16	yb_np16	yb_mc16	yb_grd16	yb_s16	yb_al16	yldbua								
CHEYENNE	17.7	24.2	17.3	46.7	9.4	63.7	53.7	53.3	43.7	47.7	29.2	37.74	60	36.96	60	55.9	142.7	45.9	22.7
GOODSTREAK	40.3	54.2	22.6	56.4	16.8	63.9	64.9	62.2	41.4	48.4	34.5	47.11	58	45.96	58	57.5	137.3	42.7	13.0
PANHANDLE	32.2	58.4	42.3	63	15.4	68.9	78	65.9	54.4	59.2	35.9	53.77	54	52.15	54	56.1	137.1	42.9	11.3
FREEMAN	36.1	69.4	59.6	106.4	37.5	72.4	99.6	94.3	72.2	74.1	58.5	72.16	5	70.92	3	55.3	134.2	38.2	19.5
NE12438-H	44.3	71.2	31.3	65.7	15.2	56.5	67.2	67	38.2	47.7	42.0	50.43	56	49.66	56	58.9	134.2	40.3	21.2
NE12439-H	57.3	71.7	54.5	82.7	43.5	81.3	88.5	75.6	54	55.2	38.9	66.43	18	63.93	19	57.5	134.3	39.9	12.0
NE14691	59.6	57.2	71.1	81.2	57.4	85.3	76.8	80.3	72.1	52.8	51.2	69.38	13	67.73	12	57.4	134.8	40.0	13.2
NI10718W	44.6	71	55.5	93.6	27.7	79.4	88.8	75.5	45.2	55	41.5	63.63	27	61.62	29	56.8	136.1	38.9	11.9
NI14729	38.8	62.6	63.9	83.1	38.7	83.8	93.4	93	66.8	61.2	45.0	68.53	15	66.39	16	57.2	137.4	40.6	12.4
NI14735	33.1	60.9	49.1	86.2	24.6	62.1	62.5	72.1	38.2	59.8	33.2	54.86	53	52.89	53	55.3	135.3	38.9	13.6
NE15434	40	65.2	53.9	89.1	43.5	78.2	81.2	76.4	46.8	54.9	44.0	62.92	29	61.20	31	59.0	136.5	37.7	12.9
NW15677	60.7	55.8	69.5	85.9	39.3	46.4	71.2	73.4	64.3	61.7	41.7	62.82	30	60.90	32	57.9	133.7	38.4	14.1
NI15713	36.1	53.4	54.6	95.1	30.3	76.5	82.7	78.4	65.3	62.7	44.4	63.51	28	61.77	26	57.4	137.0	38.8	12.4
xHF09011_306	45.9	51.1	40.1	63.2	31.4	57.4	59.8	66.4	45.9	42.2	32.9	50.34	57	48.75	57	57.9	135.6	44.1	14.8
WESLEY	31.1	58.2	47.8	99.7	31.1	75.7	70.1	69.8	52.6	55.8	37.0	59.19	48	57.17	48	55.0	136.0	37.2	11.7
OVERLAND	34.3	53.8	48.8	83.7	31.5	66.4	82.1	79.4	61.7	57.8	41.5	59.95	45	58.27	45	57.9	140.4	39.7	14.8
NE09517-1	49.6	55.9	62.2	95.2	43.2	62.1	87.7	83.2	53	56.3	47.4	64.84	21	63.25	22	59.9	135.3	40.9	13.4
RUTH	48.9	77.6	65.5	104.5	46.9	69.4	84.7	89.5	59	58.1	58.3	70.41	11	69.31	8	60.9	136.5	40.5	12.5
NI12702W	50.4	53.5	62.3	83.8	47.6	83.7	82.8	82.3	61.1	53.1	42.0	66.06	19	63.87	20	61.2	137.5	39.4	15.8
NI13706	42.1	84.4	48.9	98.7	51.1	79.5	89.7	90.7	65.7	76.4	42.9	72.72	3	70.01	7	59.4	132.9	37.7	13.4
ROBIDOUX	39.9	65.5	62.7	99.3	50.7	67.5	97	95.7	70.8	72.5	55.1	72.16	5	70.61	4	59.0	135.6	40.3	12.3
Settler CL	33.7	67.3	40.3	81.2	33.1	81.5	103.4	77.3	54.4	51.3	41.0	62.35	34	60.41	34	57.4	135.6	39.0	12.0
SCOUT66	29.5	32.8	25.5	44.4	11	48.7	65.6	54.2	38.7	53.2	30.4	40.36	59	39.45	59	55.9	134.4	44.7	12.4
NE12561	58.4	72.9	46.7	94.1	59.9	60.9	83.9	86.8	61.8	60.8	57.7	68.62	14	67.63	13	60.2	133.7	38.8	12.4
NE12589	50.5	78.1	60	79.4	36.5	58.6	71.4	76.5	49.4	65.7	53.4	62.61	32	61.77	26	59.5	134.3	39.0	13.0
NE13425	61.8	70.7	45.8	91.7	33.7	61.1	68.2	79.3	51.2	55	34.0	61.85	35	59.32	41	57.6	133.9	39.4	19.9
NE13434	66.2	74.3	63.2	87.3	40	67.3	77.6	74.6	65.2	64	54.6	67.97	16	66.75	15	57.6	134.4	40.7	12.1
NW13493	62.7	78.1	70	100	60.9	55	88.9	94.1	47.1	68.6	46.9	72.54	4	70.21	5	59.9	135.3	39.1	12.5
NE13515	59.6	58.9	72	93.7	48.3	82.3	94.5	84.5	56	66	56.0	71.58	7	70.16	6	59.1	135.4	40.3	12.6
NW13570	50.1	74.4	58.2	109.3	60.4	51.9	105.8	88.4	59.4	57.7	45.3	71.56	8	69.17	9	59.0	138.7	39.7	12.3
NW13574	64.9	62.3	40.2	77.2	30.4	65.6	73.1	71.5	51.2	59.8	52.5	59.62	47	58.97	43	59.2	138.1	43.1	18.5
NE13597	37.1	60.1	59.8	41.3	43.2	81.3	95.4	81.7	63.9	59.7	37.5	62.35	33	60.09	35	57.8	133.9	37.7	11.7
NE13604	37.4	64.3	47.7	98.7	35.9	71	88.8	90.3	51.8	61.7	48.6	64.76	23	63.29	21	59.3	139.8	40.6	12.8
NE13625	58.7	64.7	39.5	84.5	32.9	62.4	87	70.9	52.5	55.2	44.8	60.83	41	59.37	40	58.8	136.9	40.9	12.6
NW13669	48.1	61	57.5	87.1	54.1	80	67.7	89	45.9	57.9	56.8	64.83	22	64.10	18	59.0	138.7	40.5	15.0
NE13672	23	56	46.2	55.6	26.6	75.2	87	73.1	37.8	50.6	36.8	53.11	55	51.63	55	55.6	137.1	38.1	12.5
LCH13NEDH-11-24	49.5	56.9	45.2	75.5	22.2	60	79.1	69.7	46.3	50.9	34.1	55.53	52	53.58	52	59.3	141.2	43.3	14.8
PSB13NEDH-14-83W	41.8	56.3	50.1	89.7	34.4	73.8	81.8	86	51.1	52.5	48.9	61.75	36	60.58	33	59.5	137.1	40.2	13.3
NE10478-1	61.3	86.2	57	95.1	46	81.1	104	81.2	57.2	68.4	59.2	73.75	2	72.43	2	59.4	133.8	37.9	11.9
NE14419	56.1	53.7	47.7	73.6	39.7	74.5	78.6	75.9	67	46.8	46.8	61.36	38	60.04	36	58.6	141.9	42.7	13.1
NE14421	59.6	71.5	64	96.9	51.8	77.2	91	76.9	51.9	64.1	38.3	70.49	10	67.56	14	59.3	136.4	39.6	12.4
NE14434	60.6	69.4	72.8	86	48.4	77.8	60.9	93.2	64.8	71.3	50.9	70.52	9	68.74	11	59.2	136.2	40.0	16.3
NE14448	66.3	61.7	60.8	90.9	31.1	76.6	90.7	68.8	54.9	51.6	39.2	65.34	20	62.96	24	59.7	134.0	42.1	12.2
NE14457	41.7	62.2	43.7	89.5	21.8	63.8	90.5	83.2	41	59.8	42.1	59.72	46	58.12	47	58.2	140.5	40.1	13.0
NE14480	42.4	65.1	55.6	96.1	49.5	54	56	78.3	50.3	64.2	44.5	61.15	39	59.64	38	58.9	138.4	40.9	14.6
NE14494	40.8	50.2	54.7	100	50.1	62.2	79.1	80.1	52.4	57.2	48.7	62.68	31	61.41	30	58.6	138.6	41.8	15.3
NE14531	51.2	76.7	65.2	70.8	38.6	82.4	84.6	84.3	54.5	58.8	42.4	66.71	17	64.50	17	59.8	134.0	40.5	12.4
NE14538	44.8	65.9	68.6	99.2	44.8	79.9	97	80.8	51.8	67.6	56.6	70.04	12	68.82	10	59.0	135.9	39.3	11.9
NE14546	48	65.8	51.2	90.4	34.7	61.1	75.4	79.2	45.9	58	38.4	60.97	40	58.92	44	58.6	136.0	39.3	13.0
NE14569	35.1	55.1	50.7	95.7	24.9	71.8	91.3	70.3	54.7	56.7	48.9	60.63	42	59.56	39	57.2	135.5	39.9	12.8
NE14606	47	75.5	60	83.8	43.4	69.6	83.3	70.9	48.4	62.7	49.3	64.46	24	63.08	23	58.4	138.3	39.9	12.2
NE14632	58.4	65.6	48.9	79.7	30.4	72.6	70.4	73.2	47.8	55.2	38.2	60.22	44	58.22	46	56.2	142.4	45.9	12.1
NE14654	47.7	60.1	53.3	86.1	46	52	66.7	87.1	47	59.6	53.5	60.56	43	59.92	37	58.8	138.4	41.3	13.5
NE14663	59.5	66.8	53.3	81	38.5	80.3	88.8	78.6	44	51.2	46.8	64.20	25	62.62	25	57.2	134.5	41.2	12.1
NE14674	45.3	39.5	50.5	57.4	34.9	73.1	94.5	65.1	44.5	54.3	36.0	55.91	51	54.10	51	59.0	138.7	41.4	15.3
NE14686	39.9	58.4	52.3	84.4	28.8	60.2	74.3	67.3	53.3	67	25.0	58.59	49	55.54	50	57.9	135.9	39.3	12.1
NE14696	34.1	53.5	51.8	90.4	34.5	67.5	93.5	88.6	65.8	56.8	41.4	63.65	26	61.63	28	59.1	140.5	42.2	12.7
NE14700	33.1	51.5	47.2	91.7	36.2	89.4	67.6	81.8	54.7	61.7	37.4	61.49	37	59.30	42	56.1	140.0	40.1	13.6
PSB13NEDH-14-71W	54.9	78.8	67.4	102.7	61.2	85.8	99.2	82.8	64.1	57.3	52.9	75.42	1	73.37	1	60.5	135.8	38.7	12.5
OVERLAND_FHB1_1	42.6	56.8	41.3	85.4	32.1	51.2	80.2	79.5	51.4	55.8	36.7	57.63	50	55.73	49	59.3	140.3	41.7	13.1
Alpha level	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.05								
GRAND MEAN	**46.44**	**62.58**	**52.80**	**84.68**	**37.73**	**69.68**	**81.66**	**78.32**	**53.72**	**58.49**	**44.13**	**62.61**		**60.93**		**58.28**	**136.74**	**40.40**	**13.63**
LSD	16.17	16.57	17.38	38.78	12.12	15.37	31.06	14.55	17.31	12.48	**14.58**								

The 2015 Nebraska Intrastate Nursery (NIN) was planted at eight locations in Lincoln, Mead, Clay Center, McCook, North Platte, Grant, Sidney, and Hemingford, NE. Two replications at Lincoln were sprayed three times with fungicides to control disease, while two replications were not sprayed which allowed a comparison of diseased vs. largely disease free genotypes. The sites at Grant, McCook, and Alliance were also sprayed with a single application of fungicide mainly to control stripe rust. The 2015 data are:

	Mead	Linc+fung	Linc.	C. Center	N. Platte	McCook	Grant	Sidney	Alliance	Avearge	Rank	Disease	Winter	Flowering	Height	Test	Stripe
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield		effect	Survival	Date		Weight	Rust
	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)			(%)	d after Jan.1	(in)	(lbs/a)	1=R,9=S
name	yb_m15	yb_lim15	yb_l15	yb_cc15	yb_np15	yb_mc15	yb_grd15	yb_s15	yb_al15								strp_cc15
WESLEY	17.1	44.5	25.0	17.4	43.4	27.2	52.4	37.9	34.1	33.22	43	0.56	92.5	143.9	35.2	54.05	9
OVERLAND	19.7	50.0	27.2	28.1	43.8	37.1	55.9	38.7	30.0	36.72	32	0.54	75.0	146.2	37.7	57.85	7
NE06545	29.2	62.3	35.7	18.9	38.9	34.8	51.6	37.1	29.1	37.51	30	0.57	52.5	142.5	36.2	54.60	1
NE09517	19.1	44.1	24.2	32.2	45.4	30.2	48.7	34.8	34.4	34.79	38	0.55	85.0	144.1	38.2	57.45	2
NE09521	22.2	53.9	39.1	27.5	47.6	33.9	52.8	39.4	34.5	38.99	19	0.73	85.0	142.6	38.4	53.95	7
NE10478	26.1	63.7	35.2	28.8	39.7	28.0	53.3	40.1	32.6	38.61	21	0.55	67.5	141.1	34.7	56.20	6
NE10507	25.9	44.6	29.5	22.2	38.8	38.2	44.2	34.4	20.2	33.11	44	0.66	57.5	143.9	36.0	52.80	5
NE10589	25.9	69.6	37.7	38.9	42.8	31.6	55.0	41.5	39.0	42.44	6	0.54	82.5	145.2	37.4	55.15	3
NE10683	16.9	47.9	21.0	11.7	37.0	32.9	41.1	23.6	21.1	28.13	58	0.44	65.0	143.8	37.3	51.15	9
LCH13NEDH-3-31	25.8	57.9	31.3	26.1	50.1	35.0	58.0	42.6	37.9	40.52	14	0.54	77.5	143.9	34.4	56.10	7
NW07505	10.2	52.3	15.0	14.3	38.2	35.9	55.8	42.9	35.2	33.31	42	0.29	87.5	143.4	37.8	55.95	9
NW11511	18.3	59.8	28.2	28.8	45.8	31.5	43.4	32.2	24.3	34.70	39	0.47	80.0	140.3	35.1	56.10	1
NI12702W	30.4	61.4	52.1	30.5	52.8	38.1	45.0	33.1	28.4	41.31	9	0.85	82.5	145.6	36.6	60.80	1
NI13706	36.5	65.9	41.2	27.4	47.0	31.5	46.5	28.8	25.0	38.87	20	0.63	72.5	141.5	34.6	59.85	5
NI04421	22.8	53.9	33.2	30.4	40.4	37.0	51.7	34.2	35.9	37.72	29	0.62	82.5	143.0	37.2	58.10	7
Settler CL	19.3	49.9	22.2	17.0	35.2	33.1	49.7	27.1	27.5	31.22	52	0.44	85.0	142.2	34.1	58.65	9
NE12429	16.9	59.3	20.6	22.0	32.5	36.7	51.0	29.3	26.4	32.74	48	0.35	72.5	144.0	35.3	57.25	9
NE12443	28.7	56.1	40.1	31.1	41.7	41.9	48.8	33.3	23.8	38.39	25	0.71	80.0	142.3	38.3	57.80	1
NE12444	25.9	55.8	35.0	18.0	19.3	27.6	40.5	22.0	42.3	31.82	50	0.63	42.5	141.5	34.5	52.95	6
NE12488	18.3	49.6	27.3	25.0	31.3	33.4	49.6	24.8	19.4	30.97	53	0.55	67.5	142.5	37.0	52.60	8
NE12561	31.3	52.2	35.9	36.0	48.2	29.9	46.6	38.0	27.5	38.40	23	0.69	82.5	141.9	35.4	58.55	3
NE12571	21.0	57.9	23.4	23.5	37.7	38.6	52.4	35.3	30.9	35.63	35	0.40	85.0	143.6	37.7	56.65	8
NE12589	30.1	62.9	35.8	26.5	46.8	30.6	53.9	38.3	31.0	39.54	18	0.57	75.0	143.9	35.8	57.80	9
NE05548	13.6	39.1	14.7	14.5	39.6	34.5	52.2	39.6	37.3	31.68	51	0.38	95.0	145.4	41.6	51.45	9
GOODSTREAK	23.6	57.9	33.4	23.2	45.1	35.1	50.7	40.0	34.8	38.20	28	0.58	97.5	145.5	42.0	56.65	9
SCOUT66	24.3	25.7	32.4	19.8	35.8	31.4	46.1	39.6	19.2	30.48	54	1.26	87.5	143.6	42.0	57.25	5
CHEYENNE	16.8	20.2	25.0	15.1	35.9	42.8	44.6	38.9	30.9	30.02	55	1.24	87.5	149.2	45.5	53.05	6
NE13405	21.8	65.6	28.5	18.8	37.2	28.9	46.7	25.9	19.3	32.52	49	0.43	65.0	141.6	34.8	56.80	9
NE13425	36.0	44.9	37.2	37.6	47.5	38.9	45.8	44.9	32.7	40.61	12	0.83	82.5	142.2	36.6	55.25	1
NE13434	30.4	60.2	33.9	38.0	51.6	33.3	54.0	47.3	42.0	43.41	4	0.56	82.5	143.4	36.5	54.85	6
NE13445	27.1	52.7	30.8	31.8	40.3	31.5	55.0	35.3	40.9	38.38	26	0.58	82.5	142.0	38.4	55.80	5
NW13455	18.9	51.3	29.8	16.2	35.2	40.5	52.2	32.3	29.8	34.02	41	0.58	70.0	143.6	36.0	57.50	9
NE13483V	20.2	52.5	29.0	23.5	36.5	39.3	50.9	39.1	33.1	36.01	33	0.55	67.5	144.2	38.7	55.35	6
NW13493	35.3	52.1	42.8	38.3	55.6	50.8	53.6	30.9	32.1	43.50	3	0.82	75.0	144.4	35.9	58.30	1
NW13499	9.8	40.4	22.8	18.5	34.9	33.6	45.5	27.9	25.1	28.72	57	0.56	72.5	144.9	38.7	55.15	9
NE13511	18.0	50.1	21.5	26.2	39.8	42.4	54.6	30.4	39.4	35.82	34	0.43	82.5	146.4	36.0	54.90	9
NE13515	33.6	57.7	40.4	40.6	56.8	42.4	56.0	52.4	47.0	47.43	1	0.70	90.0	144.8	39.0	56.90	3
NE13554	26.4	52.6	40.4	31.6	53.4	43.0	50.7	28.5	18.3	38.32	27	0.77	75.0	147.7	40.9	56.65	1
NW13570	39.3	50.2	40.9	29.7	45.6	44.0	56.0	32.5	29.5	40.86	11	0.81	67.5	145.7	35.7	53.65	1
NW13574	17.8	43.9	26.2	36.2	45.8	39.0	52.6	47.5	36.6	38.40	23	0.60	85.0	145.4	40.6	55.45	5
NE13593	18.7	46.0	16.6	16.9	43.7	29.8	58.7	41.7	36.5	34.29	40	0.36	97.5	144.7	37.2	55.90	9
NE13597	17.9	53.9	26.5	32.5	50.8	43.2	49.0	51.9	35.9	40.18	17	0.49	92.5	143.8	35.5	54.90	6
NE13604	23.1	54.1	31.9	28.3	51.0	43.6	59.1	37.9	36.0	40.56	13	0.59	87.5	147.1	39.1	57.85	7
NE13625	27.3	63.0	29.5	26.4	52.3	36.6	57.7	43.5	37.9	41.58	8	0.47	95.0	143.3	38.1	61.45	9
NE13629	10.6	45.4	17.2	16.8	41.4	44.9	47.5	35.2	36.3	32.81	47	0.38	87.5	147.0	40.1	56.75	9
NE13660	16.8	55.6	24.7	20.5	34.4	35.5	45.1	33.8	30.3	32.97	45	0.44	60.0	147.2	35.6	57.90	4
NW13669	25.4	39.1	32.4	37.4	54.3	51.7	58.3	42.8	41.8	42.58	5	0.83	70.0	147.2	38.0	54.30	1
NE13672	8.9	62.0	17.1	17.8	41.4	35.5	55.5	26.6	30.9	32.86	46	0.28	95.0	146.2	35.9	56.95	9
NE13683	15.3	49.1	27.2	23.6	43.7	37.2	52.0	33.5	34.2	35.09	36	0.55	87.5	145.7	34.9	58.90	9
NE13687	12.8	55.6	20.0	25.6	38.0	38.3	55.7	44.0	46.5	37.39	31	0.36	77.5	148.0	36.1	55.15	5
LCH13NEDH-11-24	19.8	44.2	28.9	24.8	47.7	50.9	59.8	46.5	39.4	40.22	15	0.65	95.0	146.8	41.1	58.90	9
LCI13NEDH-14-53	16.7	51.2	25.4	31.2	45.9	36.0	59.0	48.2	48.3	40.21	16	0.50	87.5	146.6	35.0	54.25	5
PSB13NEDH-15-58W	18.3	49.3	20.2	27.7	50.2	34.4	59.5	50.0	37.1	38.52	22	0.41	95.0	144.7	36.4	56.70	6
PSB13NEDH-14-83W	27.9	60.9	33.6	41.3	50.7	41.7	53.8	37.8	44.4	43.57	2	0.55	90.0	146.8	37.6	58.30	5
NI13717	18.5	44.1	24.6	16.2	28.5	33.6	44.9	23.9	26.0	28.92	56	0.56	55.0	141.6	35.0	52.15	8
NI14721	1.6	36.2	5.1	7.8	32.6	29.4	45.6	17.5	19.2	21.67	60	0.14	67.5	144.7	34.7	52.55	8
NI14729	28.2	54.2	35.3	31.6	62.4	41.3	51.4	32.2	33.0	41.07	10	0.65	82.5	144.9	37.6	55.55	1
NI14733	7.2	33.0	12.6	11.9	29.7	29.7	50.4	35.2	26.5	26.24	59	0.38	72.5	144.0	38.1	49.25	8
NE09517-1	16.6	46.7	23.9	34.6	53.2	28.9	47.8	37.5	24.8	34.89	37	0.51	85.0	144.1	39.1	55.60	1
NE10478-1	29.1	55.9	37.7	32.2	49.4	32.8	55.7	45.2	36.8	41.64	7	0.67	92.5	140.9	34.3	56.55	8
CV	14.42	13.62	13.54	11.67	13.36	6.97	5.09	16.18	10.81				14.24	0.65	5.74	4.09	19.24
GRAND MEAN	21.86	51.54	28.93	25.79	43.02	36.35	51.34	36.45	32.34				7.95	144.31	37.22	55.96	5.88
Heritability	0.85	0.56	0.81	0.87	0.59	0.83	0.75	0.57	0.79				0.31	0.80	0.55	0.37	0.87
LSD	6.10	14.23	7.95	5.83	11.50	5.13	5.23	11.36	8.36				0.83	1.86	4.21	1.19	1.84
R-Square	0.94	0.90	0.95	0.94	0.79	0.96	0.88	0.74	0.90				0.41	0.91	0.82	0.47	0.94

Data from 2015 to 2017 (three year average) from the Nebraska Intrastate Nursery for Grain Yield (bu/a) are presented below:

	Mead		Linc.IM	Linc.	ClayCen	Nplatte	McCook	Grant	Sidney	Alliance	Average-All		Average	Average	Average
	Yield	yield	yiedl	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Rank	Testwt	Height	Hdate
Name	bu/a			bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a				
CHEYENNE	26.43	24.20	32.83	23.00	25.60	51.17	52.40	43.63	44.00	41.13	37.75	24	54.07	45.55	145.45
GOODSTREAK	41.23	54.20	59.77	33.37	31.70	52.60	57.27	49.93	45.57	47.67	47.33	22	56.36	42.25	140.09
Panhandle	33.07	58.40	56.13	33.13	28.70	52.90	65.30	55.93	52.70	49.97	48.62	21	54.01	42.30	140.13
Freeman	45.67	69.40	79.87	54.60	40.87	60.27	77.37	66.87	58.67	58.30	61.19	8	55.58	36.76	137.75
NE09517_6	40.63	55.90	69.40	42.80	48.80	57.77	70.50	55.83	49.23	45.60	53.65	18	56.80	39.97	139.32
NE10478-1	52.47	86.20	80.17	56.67	49.10	65.00	77.93	64.17	58.47	57.40	64.76	1	57.31	36.15	137.00
Ruth	47.80	77.60	88.40	61.23	54.47	58.33	75.87	64.80	54.33	55.23	63.81	3	58.01	38.79	139.81
NE12561	50.67	72.90	76.17	54.23	57.27	56.63	67.27	62.93	53.20	50.20	60.15	10	58.72	37.05	137.41
NE12589	51.60	78.10	71.10	50.43	44.47	56.13	65.97	59.17	48.73	56.97	58.27	13	58.42	37.35	138.51
NE13434	53.70	74.30	76.10	57.87	50.20	59.23	66.40	56.63	56.93	56.83	60.82	9	56.46	38.53	138.11
NE13515	50.93	58.90	75.13	61.50	53.40	67.63	78.53	66.17	56.27	57.53	62.60	5	57.66	39.45	139.40
NE13597	34.17	60.10	54.90	46.63	47.23	66.50	76.00	59.87	58.40	47.70	55.15	17	55.52	36.15	138.33
NE13604	42.80	64.30	73.13	41.70	44.20	62.13	77.90	66.73	51.53	55.20	57.96	14	57.97	40.08	142.59
Robidoux	45.67	65.50	81.03	53.53	50.97	58.40	76.33	67.17	56.57	60.90	61.61	7	58.28	38.50	138.56
NI12702W	47.73	53.50	74.93	59.70	49.43	68.77	73.30	59.70	50.63	47.97	58.57	12	59.90	38.22	140.61
NI13706	50.63	84.40	81.53	58.77	48.50	67.73	68.00	65.87	51.03	58.23	63.47	4	59.13	36.10	136.70
NI14729	45.40	62.60	61.57	51.53	44.23	71.80	78.07	68.03	55.17	54.47	59.29	11	56.63	38.78	140.38
NW13493	55.00	78.10	71.73	62.43	56.73	62.60	80.83	68.00	48.73	55.90	64.01	2	58.71	37.66	138.95
NW13570	50.23	74.40	79.93	53.07	55.90	55.70	82.83	67.87	52.80	49.50	62.22	6	56.42	37.81	140.78
OVERLAND	45.73	61.00	65.57	47.03	53.50	63.30	69.97	63.50	49.73	54.47	57.38	15	56.88	39.55	141.70
PSB13NEDH-14-83W	43.83	53.80	73.40	44.67	41.17	62.00	72.17	63.13	55.00	55.10	56.43	16	57.72	38.54	141.55
SCOUT66	41.17	56.30	65.60	40.43	41.93	58.40	62.33	60.03	46.37	50.23	52.28	20	57.62	39.72	140.51
Settler CL	32.90	32.80	48.87	36.93	30.40	50.23	61.43	50.17	47.63	39.10	43.05	23	56.21	41.21	138.04
WESLEY	36.23	67.30	66.00	41.10	36.43	61.93	72.57	59.27	46.23	44.83	53.19	19	56.73	36.06	138.61
Average	**44.40**	**63.51**	**69.30**	**48.60**	**45.22**	**60.30**	**71.11**	**61.06**	**52.00**	**52.10**	**56.81**				

As can be seen from the excellent three-year yields of released lines (Ruth, Robidoux, and Freeman), our new and released lines continue to do well, but we have many experimental lines with excellent grain yields in the east, central, or west parts of Nebraska. Of particular note is NW13493, which is a high yielding white wheat and NI13706, a new hard red winter wheat. NE12589 has very good stem rust resistance. As expected Cheyenne and Scout 66 were the lowest yielding lines. Both broadly and more narrowly adapted lines have value in wheat production.

5. **Nebraska Triplicate Nursery (NTN):**

The same comments about the NIN data apply to the NTN. Due to fewer replications, all replications of the NTN were treated with fungicides at Lincoln. Mead was lost to late rains before we could harvest the nursery and Clay Center was diseased. It was interesting to look at the three check lines in this nursery. Freeman had a great year and topped the trial. Camelot, which had a normal year, was ranked 41 and Goodstreak which is retained for it adaptation to the west, long coleoptile and height ranked 58th. Though we do not expect tall wheats to perform as well as our semi-dwarf wheat, we will look for a new tall wheats with higher grain yield. The data for 2017 are:

Name	Mead	Lincoln	ClayCent.	N.Platte	McCook	Grant	Sidney	Alliance	Average	Rank
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	
	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	
NE16424	68.60	87.70	74.50	66.60	105.30	56.70	80.10	66.50	75.75	1
NE16593	66.50	86.90	75.00	64.80	100.50	57.50	80.90	69.70	75.23	2
NE16562	67.40	89.40	78.40	63.20	90.60	58.00	83.00	63.70	74.21	3
Freeman	60.90	89.60	62.70	65.00	90.70	53.60	83.40	74.60	72.56	4
Ruth	63.50	90.50	74.70	61.30	101.40	52.30	68.30	67.10	72.39	5
NE16443	55.50	84.20	65.90	57.50	93.70	60.20	75.80	75.90	71.09	6
NE16579	67.00	83.50	64.70	64.80	102.90	48.10	67.50	67.90	70.80	7
NE16468	61.30	64.40	62.40	61.10	103.60	61.80	74.90	76.80	70.79	8
NW16563V	64.20	76.30	67.60	66.00	99.90	51.70	65.10	74.80	70.70	9
NE16451	67.60	87.40	72.30	56.70	101.00	54.70	65.00	60.30	70.63	10
NE16587	66.30	71.60	62.20	62.40	101.30	61.80	71.30	64.50	70.18	11
NW16687	66.00	79.40	71.60	62.70	107.70	53.50	62.80	57.50	70.15	12
NE16402	67.30	81.00	72.70	64.80	104.60	43.00	67.90	59.10	70.05	13
NE16467	62.20	78.40	68.40	62.10	96.70	53.80	70.00	65.70	69.66	14
NE16578	56.70	73.30	69.10	62.40	107.00	55.00	69.40	62.70	69.45	15
NE16606	62.00	77.50	65.40	60.50	103.10	53.10	70.10	62.90	69.33	16
NE16672	59.70	69.00	75.90	74.80	91.70	50.70	71.50	58.90	69.03	17
NE16640	65.00	73.80	70.10	61.50	97.80	49.00	69.80	64.60	68.95	18
NE16412	52.40	65.30	61.70	74.70	98.80	57.30	76.80	63.30	68.79	19
NE16604	68.70	71.10	67.70	62.60	99.40	49.50	67.90	58.30	68.15	20
NE16616	59.60	66.20	75.10	62.70	91.90	54.40	71.90	58.70	67.56	21
NE16596	56.40	65.00	68.40	67.10	93.70	48.60	73.60	65.30	67.26	22
NE16548	54.70	81.90	65.30	65.10	95.90	50.60	67.50	56.60	67.20	23
NE16631	50.40	80.30	71.10	59.20	89.70	50.60	68.40	66.50	67.03	24
NE16639	50.70	75.30	68.30	55.40	104.00	50.40	66.80	61.50	66.55	25
NE16554	52.70	69.40	75.10	51.80	98.60	58.80	69.10	56.60	66.51	26
NE16659	56.90	64.70	65.10	57.00	97.40	40.00	81.00	70.00	66.51	26
NE16521	56.60	67.70	65.30	58.20	94.80	50.40	72.70	65.60	66.41	28
NE16567	58.20	53.30	72.90	59.40	100.90	53.40	69.80	62.30	66.28	29
NE16588	65.50	65.70	71.90	58.60	94.90	44.20	68.10	60.60	66.19	30
NE16493	62.10	78.10	67.10	53.70	92.20	46.10	71.30	58.80	66.18	31
NE16478	49.80	74.90	68.70	61.50	92.10	50.70	71.20	56.90	65.73	32
NE16657	66.10	80.30	68.70	57.20	93.30	43.70	64.20	52.20	65.71	33
NE16612	61.10	79.10	64.80	58.40	97.10	46.60	67.50	50.90	65.69	34
NE16620	55.10	78.40	70.40	57.70	97.30	52.80	61.90	51.50	65.64	35
NHH16634	47.10	69.60	69.40	54.90	97.00	54.10	71.90	58.50	65.31	36
NE16660	53.30	69.90	69.70	56.70	96.90	50.10	67.30	58.60	65.31	36
NE16494	54.70	73.20	65.70	51.70	92.70	49.50	71.80	62.20	65.19	38
NE16576V	49.90	68.70	64.50	61.60	92.50	52.70	74.40	52.30	64.58	39
NE16648	49.90	65.20	69.00	46.20	104.90	53.10	64.00	62.70	64.38	40
NE16545	65.50	77.50	65.40	64.90	88.40	39.90	59.00	54.10	64.34	41
NE16549	57.20	73.90	62.40	65.80	85.70	40.50	71.40	56.90	64.23	42
NE16658	56.70	60.70	61.00	56.40	91.30	53.30	72.00	58.20	63.70	43
NE16479	48.40	64.50	61.70	50.00	100.90	52.70	68.90	61.90	63.63	44
NE16556	60.30	74.00	65.10	50.30	86.20	49.10	63.90	57.00	63.24	45
NE16566	68.50	58.30	61.30	56.90	91.00	48.70	69.90	51.00	63.20	46
NE16619	49.30	75.10	61.90	56.70	95.90	46.00	63.50	56.60	63.13	47
NE16439	57.20	73.50	58.20	59.60	83.30	51.20	64.50	55.50	62.88	48
NHH16422	37.70	75.20	64.70	46.50	92.00	59.40	66.30	56.10	62.24	49
NE16607	57.30	62.80	60.10	53.20	92.40	45.40	72.40	49.90	61.69	50
NE16553	39.60	60.20	67.40	59.60	92.70	43.90	72.10	56.20	61.46	51
NHH16688	46.80	62.30	61.40	64.20	89.40	45.20	63.40	58.10	61.35	52
NE16552	56.70	65.10	62.40	61.30	82.40	41.60	60.20	60.50	61.28	53
NE16401	54.80	69.40	62.10	41.70	95.20	47.40	65.30	50.30	60.78	54
NE16546	45.20	59.60	50.60	62.40	92.80	41.60	63.50	61.80	59.69	55
NW16686	56.90	65.40	62.00	68.60	76.00	41.00	61.80	39.20	58.86	56
NE16423	51.30	71.30	56.30	60.90	76.90	45.20	52.60	55.50	58.75	57
NE16438	51.10	68.80	61.90	58.20	68.70	41.60	59.20	54.90	58.05	58
Goodstreak	34.10	57.20	61.60	48.10	83.80	40.80	67.50	58.00	56.39	59
NE16673	41.40	57.50	61.80	47.30	82.90	45.70	62.10	50.90	56.20	60
Avearge	**56.93**	**72.33**	**66.48**	**59.37**	**94.39**	**50.04**	**68.92**	**60.10**	**66.07**	

The data for 2016 are:

Name		Lincol IM	Clay Cente	N. Platte	McCook	Grant	Sidney	Alliance	**Average**	**Rank**	Hdate	Height	Test Weigh
		Yield	Yield	Yield	Yield	Yield	Yield	Yield	**Yield**		Days afer		
		bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	**bu/a**		Jan.1	(in)	lbs/bu
Freeman		93.3	56.1	77.1	100.5	91.8	70.4	77.6	**81.0**	**1**	131.9	36.9	56.65
NE15624		86.0	63.6	48.0	106.1	88.8	74.0	71.0	**76.8**	**2**	134.6	34.5	56.98
NE15445		76.0	57.3	87.9	100.8	75.1	75.2	50.3	**74.7**	**3**	132.3	35.0	55.85
NE15406		88.8	57.6	68.7	85.3	85.6	70.4	63.5	**74.3**	**4**	133.1	37.2	57.83
NE09517_6		80.0	52.9	77.6	89.6	78.3	62.9	65.3	**72.4**	**5**	134.8	39.1	60.38
NE15605		78.3	57.6	77.0	81.4	74.6	69.1	62.2	**71.5**	**6**	137.7	38.1	58.50
NE15410		73.4	53.3	55.7	90.7	86.4	68.8	62.9	**70.2**	**7**	131.1	38.0	56.75
NE15440		73.8	47.2	81.0	87.2	77.1	65.7	57.7	**70.0**	**8**	133.0	37.3	53.05
NW15404		83.5	62.9	49.3	80.7	76.9	74.0	61.7	**69.9**	**9**	133.3	35.7	58.63
NE15571		74.4	56.7	56.0	77.1	82.6	71.2	70.1	**69.7**	**10**	138.0	35.6	56.73
NE15405		68.0	51.7	75.9	83.7	74.6	73.5	60.0	**69.6**	**11**	131.9	39.5	57.50
NE15468		85.5	41.8	77.7	95.5	73.1	52.8	57.6	**69.1**	**12**	132.7	37.9	56.23
NW15443		96.2	52.3	64.1	87.3	74.8	52.2	57.1	**69.1**	**13**	138.0	38.5	55.63
NW15573		71.0	47.9	70.0	72.9	85.8	70.8	63.3	**68.8**	**14**	136.0	36.0	58.03
NE15434		76.2	45.5	71.2	88.8	71.7	66.0	58.7	**68.3**	**15**	135.0	37.3	56.55
NE15545		81.8	51.7	79.0	83.3	67.2	66.9	47.8	**68.2**	**16**	137.3	39.5	56.73
NW15485		88.0	61.0	46.2	64.4	86.4	65.8	63.4	**67.9**	**17**	132.7	33.1	58.18
NE15475		76.6	36.4	81.8	80.9	70.9	71.2	56.8	**67.8**	**18**	134.0	41.2	56.03
NE15417		84.6	42.6	79.1	71.1	74.6	65.0	54.4	**67.3**	**19**	134.1	35.7	53.58
NW15564		88.4	57.4	52.6	75.1	68.9	67.8	60.3	**67.2**	**20**	133.6	35.8	58.53
NW15684		90.5	45.9	67.6	91.5	78.1	43.1	53.0	**67.1**	**21**	139.0	38.5	56.85
NE15495		75.7	42.8	76.5	80.8	69.1	62.1	62.3	**67.0**	**22**	134.0	36.8	56.58
NE15689		83.5	58.6	48.2	75.2	71.6	74.9	52.4	**66.3**	**23**	132.6	39.1	59.18
NW15667		89.2	40.7	63.9	77.8	76.2	55.8	59.6	**66.2**	**24**	134.0	36.5	57.65
NE15519		72.9	44.3	63.1	80.2	77.8	62.9	60.4	**65.9**	**25**	131.9	39.3	55.63
NE15415		83.3	41.5	71.4	68.4	81.8	57.3	56.1	**65.7**	**26**	134.3	41.1	58.45
NE15595		77.2	48.7	32.6	88.7	83.6	67.1	60.5	**65.5**	**27**	139.7	37.5	59.33
NE15525		76.0	43.2	68.7	78.7	73.9	57.7	59.5	**65.4**	**28**	138.3	37.0	55.95
NE15668		72.4	39.7	71.6	85.6	71.9	55.3	60.7	**65.3**	**29**	136.4	37.3	51.00
NW15677		78.3	50.4	54.1	77.7	72.4	64.8	58.4	**65.2**	**30**	132.7	35.5	55.85
NE15655		63.3	40.7	75.7	94.2	61.9	65.9	54.0	**65.1**	**31**	140.4	34.6	53.65
NE07486_2		85.0	39.7	48.3	87.9	63.6	69.6	60.1	**64.9**	**32**	139.4	39.6	58.70
NE15572		73.4	45.4	71.2	71.4	70.6	65.9	55.6	**64.8**	**33**	138.3	39.5	54.68
NE15645		85.7	44.5	63.7	87.3	61.7	57.4	47.2	**63.9**	**34**	135.4	42.1	56.45
NE15508		75.3	52.4	48.5	59.7	74.6	76.1	58.3	**63.6**	**35**	131.0	34.3	58.15
NE15620		79.9	28.8	68.0	83.4	73.5	60.7	47.6	**63.1**	**36**	137.3	40.0	49.23
NE15614		76.1	37.0	67.9	76.1	70.2	58.0	55.1	**62.9**	**37**	138.3	39.3	56.50
NE15503		63.1	42.6	68.7	79.3	62.1	67.5	56.7	**62.9**	**38**	134.0	42.3	51.70
NE15662		74.7	40.2	60.8	64.5	74.7	70.6	54.5	**62.9**	**38**	141.0	39.6	57.48
NE15628		79.9	50.6	42.0	66.1	80.6	64.4	55.5	**62.7**	**40**	131.0	37.4	58.58
Camelot		65.2	28.3	70.3	83.6	73.8	54.3	62.9	**62.6**	**41**	132.6	39.0	55.83
NH144913-3		80.3	26.5	67.0	75.7	73.2	57.0	57.9	**62.5**	**42**	131.0	35.1	54.90
NE15683		71.7	25.4	73.9	91.1	69.1	52.0	53.0	**62.3**	**43**	131.4	37.3	57.13
NE15636		74.7	48.5	30.1	63.4	79.0	72.3	66.1	**62.0**	**44**	131.7	33.3	56.55
NH144922-1		74.7	31.1	67.3	76.3	72.9	50.8	60.0	**61.9**	**45**	132.6	37.2	52.85
NE15686		72.8	33.5	63.3	75.1	76.2	60.2	51.2	**61.8**	**46**	134.6	37.5	55.78
NW15466		68.5	52.2	45.6	84.9	65.6	63.2	46.7	**61.0**	**47**	140.3	39.2	57.83
NH144921-1		73.9	39.4	38.5	75.8	72.2	61.5	64.6	**60.8**	**48**	131.4	35.9	55.68
NH144925-4		79.1	25.1	61.9	64.3	70.5	56.5	65.7	**60.4**	**49**	135.0	38.7	56.25
NE15630		82.0	37.9	66.2	70.4	63.2	57.1	44.8	**60.2**	**50**	132.0	36.3	57.43
NE15654		74.9	28.6	66.9	81.3	68.8	51.4	48.2	**60.0**	**51**	138.3	38.5	56.75
NE15619		77.5	40.3	40.7	73.7	68.5	59.7	57.8	**59.7**	**52**	135.0	39.4	57.48
NE15474		64.8	40.0	55.7	82.2	65.5	57.6	50.3	**59.4**	**53**	141.1	38.9	57.80
NE15651		53.8	34.6	68.8	69.4	65.4	59.3	47.6	**57.0**	**54**	140.3	44.6	57.88
NE15460		70.6	31.8	56.6	84.9	54.9	54.2	44.1	**56.7**	**55**	134.6	40.3	57.15
NE15641		60.5	24.7	50.6	76.9	70.6	47.6	52.7	**54.8**	**56**	134.3	40.6	56.10
NE15675		66.3	28.0	60.1	72.4	56.0	50.7	42.5	**53.7**	**57**	137.4	43.3	57.05
GOODSTREAK		58.2	21.9	56.6	64.1	57.3	47.2	57.1	**51.8**	**58**	136.7	41.9	55.30
NE15691		65.1	27.9	41.2	64.7	67.7	43.1	46.8	**50.9**	**59**	135.0	41.7	58.23
NE15419		48.8	34.5	66.1	61.1	53.5	45.9	39.2	**49.9**	**60**	137.0	43.0	57.10
GRAND MEAN		**76.05**	**43.19**	**62.60**	**79.47**	**72.65**	**61.87**	**56.80**	**64.7**			**38.2**	
CV		**11.13**	**11.17**	**13.20**	**12.64**	**5.51**	**10.45**	**10.78**					
LSD		**16.39**	**9.34**	**20.09**	**24.42**	**9.73**	**10.50**	**9.94**					

The data for 2015 are:

TRP15	Mead	Lincoln	Clay Cen.	N. Platte	McCook	Grant	Sidney	Alliance	Average	Rank
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	
Name	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	
NE14401	11.9	54.6	25.1	37.2	35.5	42.7	47.4	28.6	35.4	40
NE14412	7.4	50.4	21.6	35.5	39.7	43.2	30.6	34.8	32.9	50
NE14416	10.3	58.5	20.0	31.5	33.7	44.9	35.0	35.3	33.7	48
NE14419	27.0	51.3	35.9	39.4	40.8	37.1	48.2	31.1	38.9	15
NE14421	17.5	43.1	44.9	50.6	35.6	51.3	52.0	46.2	42.7	7
NE14427	13.6	63.8	22.1	42.0	34.7	40.4	44.4	36.3	37.2	30
NE14428	7.4	41.9	16.1	39.3	34.6	37.7	36.4	35.3	31.1	55
NE14431	6.2	58.4	16.0	38.7	37.5	52.3	40.1	33.7	35.4	41
NE14434	23.6	66.4	43.1	47.3	41.9	57.1	49.4	38.0	45.9	4
NE14436	4.8	51.0	25.1	22.6	35.5	34.2	30.2	34.6	29.8	59
NE14442	13.5	50.1	21.2	36.7	25.9	40.2	36.8	27.4	31.5	54
NE14448	17.2	57.6	35.2	52.6	42.7	53.8	42.2	37.9	42.4	8
NE14449	8.1	58.2	15.3	39.4	39.7	48.9	35.9	41.9	35.9	36
NE14457	4.9	55.9	21.8	43.8	47.5	50.8	44.3	36.4	38.2	18
NE14480	9.7	58.0	30.3	45.5	38.1	50.6	52.2	42.1	40.8	10
NE14484	8.2	48.3	20.0	40.4	44.4	48.8	27.1	26.0	32.9	49
NE14492	2.9	47.7	14.9	31.6	34.4	46.3	26.7	37.3	30.2	58
NE14494	27.1	71.7	45.0	63.6	38.9	48.8	46.5	40.0	47.7	2
NE14495	13.9	54.7	26.2	33.4	34.5	50.2	31.7	25.9	33.8	47
NE14496	11.1	55.0	28.1	39.0	34.8	54.7	41.8	35.4	37.5	26
NE14498	13.2	48.2	28.3	43.2	43.2	39.2	44.9	23.1	35.4	38
NE14500	3.9	56.5	10.2	33.7	37.9	47.0	21.8	33.1	30.5	57
NE14502	7.6	50.4	17.9	43.9	37.5	45.1	26.8	26.4	32.0	52
NE14511	9.4	44.7	33.9	40.2	38.1	51.5	40.8	32.8	36.4	34
NE14523	20.8	48.8	28.6	40.8	33.8	41.5	25.1	21.7	32.6	51
NE14531	22.1	63.5	36.3	48.3	38.4	56.6	38.1	30.1	41.7	9
NE14534	16.7	46.0	33.0	47.0	32.0	35.0	47.5	32.2	36.2	35
NE14538	23.7	56.1	28.9	52.1	43.4	41.7	45.0	34.3	40.7	11
NE14545	7.8	45.1	26.2	36.4	45.4	44.4	44.4	33.5	35.4	39
NE14546	24.9	53.3	32.5	46.7	33.7	47.2	44.2	38.8	40.2	13
NHH14550	13.8	62.8	20.1	31.1	27.9	39.9	30.2	21.3	30.9	56
NE14557	10.0	52.4	19.5	41.4	39.2	41.4	41.1	35.1	35.0	44
NE14561	15.5	54.1	21.7	49.8	31.1	51.2	40.6	39.8	38.0	22
NE14563V	9.4	49.5	20.6	47.6	38.8	49.7	46.5	38.9	37.6	25
NE14569	13.7	58.9	22.4	48.7	32.4	45.3	45.6	42.4	38.7	16
NE14575	19.3	45.2	30.7	51.6	43.7	38.9	32.7	32.9	36.9	32
NE14594	14.3	51.6	25.7	46.7	32.7	52.3	40.9	33.9	37.3	27
NE14604	7.2	58.9	16.8	36.9	35.7	50.9	40.0	35.8	35.3	42
NE14605	8.3	48.7	18.4	41.7	36.2	41.8	45.1	32.1	34.0	45
NE14606	23.0	57.9	38.4	59.7	42.6	53.1	59.7	43.0	47.2	3
NE14607	4.3	56.3	19.3	43.0	34.6	49.6	43.1	36.5	35.8	37
NE14617	6.1	48.6	25.3	42.2	34.7	50.8	41.8	32.7	35.3	42
NE14629	11.6	55.4	22.5	31.6	34.3	39.5	16.3	22.1	29.2	60
NE14632	6.4	51.7	23.6	53.0	40.3	41.8	48.5	36.8	37.8	23
NE14651	10.1	60.4	17.3	31.1	31.2	39.3	31.5	31.9	31.6	53
NE14654	20.8	54.8	26.6	47.4	48.1	44.5	38.8	36.5	39.7	14
NE14656	8.8	57.2	20.7	38.6	34.1	46.4	48.2	43.5	37.2	28
NE14658	6.8	66.1	17.1	33.5	39.2	43.0	21.7	44.4	34.0	46
NE14663	16.5	62.1	34.2	41.3	38.2	53.1	39.7	19.8	38.1	20
NE14666	20.4	49.2	38.1	41.8	38.5	42.2	34.8	32.4	37.2	29
NE14672	21.9	49.8	35.5	40.8	44.8	43.4	40.3	29.8	38.3	17
NE14674	19.5	56.3	35.4	49.7	36.6	51.2	51.1	41.7	42.7	6
NE14686	11.5	56.4	22.5	44.4	45.7	54.1	51.3	37.6	40.4	12
NE14688	18.7	66.7	24.1	42.4	47.9	43.3	31.5	16.8	36.4	33
NE14695	8.4	62.9	23.0	46.1	37.3	52.4	35.8	35.6	37.7	24
NE14696	30.5	61.6	44.6	51.8	47.7	60.6	57.2	47.7	50.2	1
NE14700	10.8	50.8	34.5	57.0	46.3	53.6	59.5	38.0	43.8	5
GOODSTREAK	15.7	60.8	22.7	42.1	43.5	49.7	38.9	31.8	38.2	19

Freeman	15.9	55.8	27.5	49.2	37.2	44.2	43.3	31.2	38.0	21
NI04421	14.9	52.4	28.4	36.3	33.5	50.0	46.2	33.8	36.9	31
CV	21.72	11.01	12.88	13.90	10.22	6.23	14.54	11.86		
GRAND MEAN	**13.50**	**54.75**	**26.35**	**42.66**	**38.13**	**46.68**	**40.32**	**34.07**	**37.06**	
Heritability	0.83	0.44	0.85	0.54	0.54	0.78	0.68	0.68		
LSD	5.68	11.67	5.51	14.18	9.47	7.07	11.35	8.08		

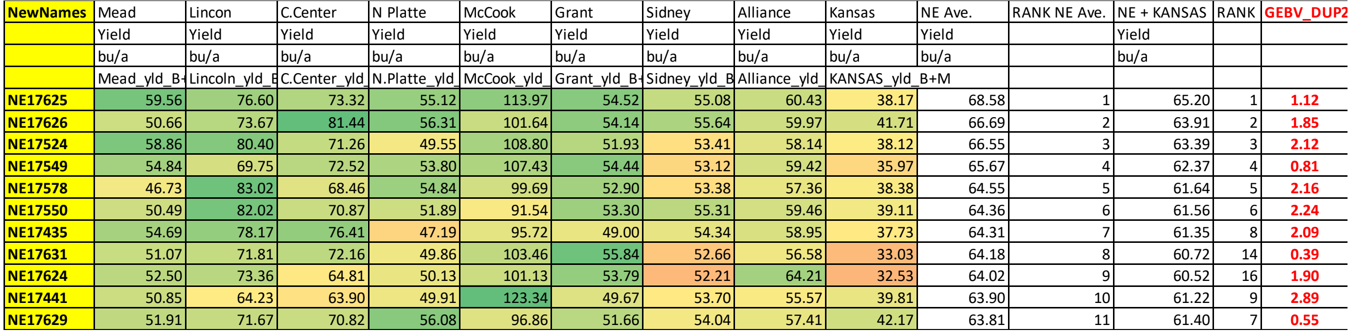
6. Regional Nurseries

In 2017, we continued to combine the Southern Regional Performance Nursery (SRPN) and the Northern Regional Performance Nursery (NRPN) into one larger nursery. These were planted at Lincoln, North Platte, Sidney, and Alliance. At Clay Center, only the SRPN was planted. To fill out the nursery, we added a few other lines mainly to compare selections out of research for scab tolerance or drought tolerance to determine if they had merit. The NRPN and SRPN data from all locations is available at: http://www.ars.usda.gov/Research/docs.htm?docid=11932. It was useful to see Kharkof and Scout 66, older wheat cultivars, continue to be very low yielding, indicating that breeding has made ongoing and continued progress.

Name	Lincoln	N. Platte	Sidney	Alliance	Average		**ClayCen**	**Average**	**Rank**
	Yield	Yield	Yield	Yield	Yield		Yield	Yield	
	bu/a	bu/a	bu/a	bu/a	bu/a		bu/a	bu/a	
Kharkof	30.9	36.1	40.6	37.7	36.33	**89**	44.3	37.92	50
Scout 66	29.8	50	48.8	51.7	45.08	**86**	56.4	47.34	48
TAM107	52.5	55.4	58.5	53.8	55.05	**75**	55.3	55.10	45
Jagalene	68.4	56.9	53.2	59.9	59.60	**56**	63.0	60.28	38
N13MD2589W	30.3	45.5	48.1	35.1	39.75	**88**	51.1	42.02	49
OK12716	64.8	72.5	64.3	63.2	66.20	**22**	71.4	67.24	18
OK12DP22002-042	80.7	71.6	67.9	53.6	68.45	**11**	75.7	69.90	8
OK12D22004-016	91.1	63.1	66.2	69	72.35	**3**	73.0	72.48	3
OK13209	69.9	63.3	51.6	42.9	56.93	**69**	66.8	58.90	44
OK12D22002-077	66.1	67.2	66.1	52.3	62.93	**40**	67.2	63.78	30
OK13621	78.8	60.5	63.9	49.5	63.18	**39**	69.0	64.34	27
NW13493	84.4	70	63.7	59.1	69.30	**7**	73.8	70.20	7
NE13515	72.5	64.4	60.4	48	61.33	**49**	74.7	64.00	29
NW13570	76.8	67.4	62.4	55	65.40	**26**	73.1	66.94	19
NE10478-1	85.3	69.8	66.6	64.1	71.45	**5**	73.2	71.80	5
KS13H9-1	70.9	67.6	69.4	58.2	66.53	**19**	77.6	68.74	12
KS13HW92-3	73.4	52.9	52.6	53.9	58.20	**66**	79.0	62.36	34
KS14H90-5-1	66.9	76.3	69.2	57.7	67.53	**15**	77.2	69.46	10
CO12D1770	66.1	66.9	78.7	65.1	69.20	**8**	75.7	70.50	6
CO13D1783	43.5	79.5	71.3	67.2	65.38	**27**	62.1	64.72	25
CO13003C	65.8	71.8	67.9	70.7	69.05	**9**	72.6	69.76	9
CO12D2011	81.8	63.7	66.8	56.3	67.15	**16**	70.7	67.86	14
CO13D1383	80	68.7	73.1	66.8	72.15	**4**	78.1	73.34	2
CO13D1299	87.9	74.2	73.6	78.2	78.48	**1**	80.5	78.88	1
LCH13-048	79.4	58.5	60.1	68.3	66.58	**18**	65.2	66.30	22
LCH13NEDH-12-27	86	56.1	58.1	55.2	63.85	**37**	62.0	63.48	31
LCH14-051	75.3	54.4	60.4	60.6	62.68	**45**	61.8	62.50	33
LCH14-077	73.8	69.2	65.3	55.2	65.88	**25**	74.1	67.52	17
LCH14-089	66.7	52.5	59.1	55.5	58.45	**64**	65.4	59.84	41
LCH14-091	66.3	59	62.2	55	60.63	**53**	65.1	61.52	35
H4N12-0038	80.6	56	58.1	56.1	62.70	**44**	65.5	63.26	32
AP-16CP010066	78.7	66.9	70.6	58.4	68.65	**10**	67.5	68.42	13
AP-16CP010093	73	70.2	54.7	55.2	63.28	**38**	70.5	64.72	25
AP-16CP010016	58	76.1	55.7	45.6	58.85	**62**	60.8	59.24	42
AP-16CP010069	79.9	71.2	61.1	48.7	65.23	**29**	73.0	66.78	20
KS061193K-2	81.5	76.9	66.8	65	72.55	**2**	69.7	71.98	4
KS061470M-4	82.4	60.6	60.9	62	66.48	**20**	71.8	67.54	16
KS080448*C-102	72.3	65.2	63.9	56	64.35	**34**	75.0	66.48	21
KS080093M-18	81.5	68.8	68.4	51.7	67.60	**14**	74.9	69.06	11
KS080679K-3	76.9	62.5	63.4	54	64.20	**35**	68.2	65.00	24
TX12A001106	77	68.9	63.9	55.3	66.28	**21**	73.6	67.74	15
TX12A001041	65.1	45.6	57.8	59.2	56.93	**69**	72.7	60.08	40
TX12V7220	71.1	52.9	42.1	39.4	51.38	**80**	40.0	49.10	47
TX12V7229	80.3	62.1	50.3	58.8	62.88	**43**	68.8	64.06	28
TX12V7415	83.6	59.7	61.3	59.2	65.95	**24**	67.2	66.20	23
TX12A001638	83.9	51.2	55.5	47.1	59.43	**58**	63.4	60.22	39
TX13A001069	37.4	52.9	52.9	53.4	49.15	**81**	54.2	50.16	46
TX13A001169	77.3	57.6	45.9	45.4	56.55	**71**	75.2	60.28	37
TX13M5580	76.8	57.4	56.5	52.1	60.70	**52**	60.3	60.62	36
TX13M5625	80.4	60.2	51.6	44.8	59.25	**60**	58.8	59.16	43
OVERLAND	60.5	56	60.3	59.7	59.13	**61**			
WESLEY	56.5	71.1	54.5	55.9	59.50	**57**			
Jerry	35	47.1	52.4	46.6	45.28	**85**			
Overland FHB-10	58.7	57.3	59.4	49.9	56.33	**72**			
NE13434	77	62.9	64.4	56.8	65.28	**28**			
NE13604	63.4	66	56.2	60.3	61.48	**48**			
NE14448	59	61.1	60.1	43.8	56.00	**73**			
NE14434	79.7	70.1	61.2	62.8	68.45	**11**			
NE14538	80.8	68.8	56.5	61.7	66.95	**17**			
NE14606	69	71.7	57.2	59.8	64.43	**33**			
NE14663	61.2	67.3	52.2	52.8	58.38	**65**			
NHH144913-3	58.3	78.3	50.4	56.6	60.90	**51**			
PSB13NEDH-7-140	64.5	55.9	66.8	54.9	60.53	**54**			
PSB13NEDH-7-45	57	61.5	58.8	59.9	59.30	**59**			
LCH14-052	71.7	59.5	65.3	55.2	62.93	**40**			
LCH14-055	70.7	52.6	66.8	57.7	61.95	**47**			
AP-16CP010080	84.4	70.8	55.7	48.1	64.75	**30**			
AP-16CP010076	80.9	65	67.5	58.1	67.88	**13**			
AP-16CP010077	82.4	77.9	59.1	59.4	69.70	**6**			
AP-16CP010074	79.8	58.8	56	57	62.90	**42**			
14Nord-01	32.4	58.7	47.8	37.3	44.05	**87**			
15Nord-08	43.3	54.4	50.1	43.1	47.73	**83**			
15Nord-25	44.4	58.6	49.8	41.3	48.53	**82**			
15Nord-32	28.4	31.3	31.5	26.7	29.48	**90**			
SD110060-7	55.5	68.5	62.2	54.3	60.13	**55**			
SD10W153	78.9	69.5	60.3	39.8	62.13	**46**			
SD12008-2	73.5	56.7	57.7	56.7	61.15	**50**			
SD13052-1	53.5	64.5	58.6	54.7	57.83	**67**			
SD13062-2	50	68.7	59.8	56.2	58.68	**63**			
SD13090-7	54.4	57.6	57.8	52.8	55.65	**74**			
SD13117-1	51.3	60.5	52.8	51.6	54.05	**78**			
SD13W064-7	62.3	74.5	59.9	58.8	63.88	**36**			
SD14113-3	61.9	74.4	58	63.8	64.53	**32**			
SD14115-5	72.2	68.5	62.2	55.7	64.65	**31**			
MT1444	33.7	62.8	61.3	58.6	54.10	**77**			
MT1465	45.9	53.8	61.9	54.2	53.95	**79**			
MT1471	57.5	54.2	62.8	56.2	57.68	**68**			
MT1488	38.1	49.6	51	42.6	45.33	**84**			
MTW1491	42.7	56.5	61.5	57.8	54.63	**76**			
NE10589	84.9	62.1	60.9	56.7	66.15	**23**			
GRAND MEAN	66.43	62.37	59.34	54.69			67.72		
CV	13.09	8.59	12.51	11.67			8.35		
LSD	16.72	10.31	14.28	10.31			10.99		

7. Multiple-Location Observation Nursery

All eight locations in Nebraska (Lincoln, Mead, Clay Center, North Platte, McCook, Grant, Sidney, and Alliance) and one in Kansas were planted and harvested. To better estimate the yield at key locations, two replications were planted at Lincoln (but only one was harvested). The table below gives the grain yields for all of the harvested locations, the line average, and the rank of the top 10 highest yielding lines**.** In this nursery, we continued to use marker-assisted selection for line advancement. For the fifth year, we used genotyping by sequencing (GBS). Genotyping by sequencing was done in collaboration with Dr. Jesse Poland, KSU, because it is much less costly (less than 1/3 of the cost of other marker systems). The top eleven lines out of 270 experimental lines are below:



NewNames	Mead	Lincon	C.Center	N Platte	McCook	Grant	Sidney	Alliance	Kansas	NE Ave.	RANK NE Ave.	NE + KANSAS	RANK	**GEBV_DUP2**
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield		Yield		
	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a		bu/a		
	Mead_yld_B	Lincoln_yld_	C.Center_yld_	N.Platte_yld_	McCook_yld_	Grant_yld_B	Sidney_yld_B	Alliance_yld_	KANSAS_yld_B+M					
NE17625	59.56	76.60	73.32	55.12	113.97	54.52	55.08	60.43	38.17	68.58	1	65.20	1	**1.12**
NE17626	50.66	73.67	81.44	56.31	101.64	54.14	55.64	59.97	41.71	66.69	2	63.91	2	**1.85**
NE17524	58.86	80.40	71.26	49.55	108.80	51.93	53.41	58.14	38.12	66.55	3	63.39	3	**2.12**
NE17549	54.84	69.75	72.52	53.80	107.43	54.44	53.12	59.42	35.97	65.67	4	62.37	4	**0.81**
NE17578	46.73	83.02	68.46	54.84	99.69	52.90	53.38	57.36	38.38	64.55	5	61.64	5	**2.16**
NE17550	50.49	82.02	70.87	51.89	91.54	53.30	55.31	59.46	39.11	64.36	6	61.56	6	**2.24**
NE17435	54.69	78.17	76.41	47.19	95.72	49.00	54.34	58.95	37.73	64.31	7	61.35	8	**2.09**
NE17631	51.07	71.81	72.16	49.86	103.46	55.84	52.66	56.58	33.03	64.18	8	60.72	14	**0.39**
NE17624	52.50	73.36	64.81	50.13	101.13	53.79	52.21	64.21	32.53	64.02	9	60.52	16	**1.90**
NE17441	50.85	64.23	63.90	49.91	123.34	49.67	53.70	55.57	39.81	63.90	10	61.22	9	**2.89**
NE17629	51.91	71.67	70.82	56.08	96.86	51.66	54.04	57.41	42.17	63.81	11	61.40	7	**0.55**

8. Early Generation Nurseries

a. Single-plot Observation Nursery

Sixteen hundred and eighty lines were evaluated at Lincoln in 2017. Of the 1680 lines and checks, approximately 1499 were red or segregating red and white1and 224 were white or segregating red and white seeded, 202 lines were two-gene herbicide tolerant lines, 55 were WSMV resistant lines, 5 Hessian fly-tolerant lines, and 6 had waxy parents. All 1680 lines were harvested to get better information than through visual selection. We also did genotyping by sequencing (GBS) on all of the lines (thanks to cooperation with Dr. Jesse Poland). The Seed Quality Lab did an excellent job of evaluating our selections and eliminating poor quality lines before planting. Two hundred seventy lines were advanced.

b. Headrow Nursery

In 2016-17, 38,560 conventional and 4640 2-gene herbicide tolerant headrows were planted at Lincoln. In general, the headrow nursery was the preferred size. Thirteen hundred and twenty conventional lines and 235 2-gene imi-tolerant lines were selected for advancement. In addition to poor plant types, the main selection criteria for discarding headrows was poor seed quality or seed diseases. This is slightly lower than preferred but fit the budget needs for this year.

c. F_3 bulk hybrids

The F_3 bulk hybrid nursery contained 1171 red, red and white segregating, or white seeded conventional bulks. In addition, most bulks were planted at Mead (our main and best winter killing site) and many of those were planted at Sidney as a backup site in case of disaster at Mead. In addition, 66 2-gene imi-tolerant bulks were planted. The number of F_3 bulks is where we wanted it. Forty-eight thousand two hundred and forty conventional and 3520 2-gene imi-tolerant head rows were selected for fall planting in 2017. The headrows were planted late due to heavy reains in late September and early October. In general, their emergence and stands were very good in the fall. The project goal remains to have sufficiently good segregating F_3 material to select about 40 - 45,000 headrows so were were a little high this year.

d. F_2 bulk hybrids

The F_2 bulk hybrid nursery contained 1065 bulks and check plots that were planted at Mead. One hundred seventy F_2 bulks with two genes for herbicide resistance were planted at Lincoln for selection. The bulks generally survived the winter, but some were winterkilled (those involving winter tender parents). We were high on the number of F_2 bulks with 2-genes for herbicide resistance because our seed increase blocks had an error and we thought it better to kill the bulk than miss an imi-bulk.. Bulks were dropped mainly for disease or lodging and 973 conventional and 111 2-gene herbicicde tolerant F_3 bulks were planted for selection in 2018.

9. Winter Triticale Nursery

In 2015, it appeared that NE422T has good forage potential for the southern Great Plains. We are beginning to move to higher and more consistent grain yield levels and much better seed quality, but identifying excellent forage types requires forage harvesting which is expensive and difficult for widespread trials. NE441T continues to be an excellent forage triticale also. Though the markets for biofuels fluctuate with the price of oil and other geologically based fuels, we believe that there is a future for triticale in a biobased energy system. Triticale can be grown over the winter as forage or grain crop in areas where maize cannot be grown successfully. The grain will substitute for maize in animal rations and the forage can be used as forage, cellulosic ethanol feed stocks, or as a ground cover, an emerging market. Note no forage data was collected in 2017 due to equipment breakdowns and a problem with planting.

The grain yield data for 2017 are:

	Mead	Lincoln	Sindney	St. Avg.	Rank	Height	Flowering date
NewName	Yield	Yield	Yield	Yield			d after Jan. 1
	lbs/a	lbs/a	lbs/a	lbs/a		inches	days
NT16401	3425	3991	3144	3520.0	16	52.4	137.1
NT16402	4399	5315	4049	4587.7	1	47.8	134.2
NT16403	3236	3691	3867	3598.0	12	54.0	139.7
NT16404	3004	2992	3447	3147.7	22	60.2	138.2
NT16405	2479	2153	2925	2519.0	28	57.6	140.3
NT16406	3148	2152	2766	2688.7	26	58.3	142.3
NT16407	4268	3143	3668	3693.0	9	55.9	141.1
NT16408	3008	4326	3529	3621.0	11	48.2	135.5
NT12404-1	4204	5344	3459	4335.7	3	49.2	136.3
NT12425-1	3512	4256	4319	4029.0	4	45.0	136.1
NE422T	2904	2042	2409	2451.7	29	64.8	145.4
NT05421	3439	3624	2884	3315.7	20	54.6	139.3
NT06422	3116	3517	3573	3402.0	18	55.5	136.4
NT06427	2881	3720	3368	3323.0	19	47.5	138.2
NT07403	3090	4124	3577	3597.0	13	47.0	133.9
NT09423	2588	2830	3407	2941.7	23	49.1	140.2
NT11428	3482	3421	3855	3586.0	14	57.4	139.5
NT12403	3613	4532	3430	3858.3	6	50.4	136.2
NT12406	3080	3318	3931	3443.0	17	53.2	138.8
NT13416	3776	4454	3714	3981.3	5	53.8	137.4
NT14407	3552	4107	3487	3715.3	8	51.7	135.3
NT14433	2860	2744	2943	2849.0	25	61.3	138.5
NT15406	4011	5085	3919	4338.3	2	48.4	133.8
NT15421	2989	3796	2864	3216.3	21	52.7	136.5
NT15425	2592	3471	2633	2898.7	24	57.8	137.2
NT15428	3563	3960	3866	3796.3	7	51.3	136.4
NT15440	3677	4074	3313	3688.0	10	54.5	139.9
NT441	2623	1918	2466	2335.7	30	61.5	144.4
OVERLAND	2741	2400	2850	2663.7	27	41.6	141.0
NT09404-1	3073	3937	3589	3533.0	15	53.5	139.3
GRAND MEAN	**3277.76**	**3614.56**	**3375.01**	**3422.443**		53.2	138.3
LSD	671.11	558.37	711.1				
CV	12.53	9.45	12.8				

The grain and forage yield for 2016 are: Note Lincoln site was affected by hail so we present average performance with and without the Lincoln grain yields included.

	Mead	Linc.	Sidn.	Avg.	M&S Avg.		TstWt	Protein	Moisture	Hdate	Height	Bacteria	**Forage**	**Forage**
	Grain Yld	Grain Yld	Grain Yld	Grain Yld	Grain Yld	**Rank**		Wheat Adj.		Julian		Streak	**Yield**	**Dry Matter %**
name	lbs/a	lbs/a	lbs/a	lbs/a	lbs/a		lbs/bu	%	%	D after Jan.1.	(in)	(1-9)	**lbs/a**	**%**
NT05421	3257	1872	3250	2793.0	3253.5	**7**	49.9	15.7	9.3	137.9	55.0	2.3	15593	0.282
NT06422	2445	1573	3066	2361.3	2755.5	**21**	46.3	15.3	8.7	137.1	52.0	3.1	12930	0.28
NT07403	3457	2617	2993	3022.3	3225.0	**10**	48.8	14.2	9.1	134.4	48.6	2.4	13074	0.288
NT12403	2936	2512	4074	3174.0	3505.0	**3**	49.8	14.5	9.3	135.6	50.0	4.1	12161	0.284
NE422T	1573	962	3149	1894.7	2361.0	**28**	50.4	16.6	9.6	148.2	61.3	1.5	11827	0.219
NT13416	3573	1943	3976	3164.0	3774.5	**1**	50.5	14.6	9.5	136.8	52.9	2.2	12918	0.286
NT13443	3185	1860	2723	2589.3	2954.0	**16**	50.9	16.6	9.1	141.1	60.2	1.2	14180	0.284
NT09423	1983	2312	3815	2703.3	2899.0	**17**	48.1	15.6	9.6	139.9	52.1	2.2	12029	0.275
NT11428	3471	2038	3359	2956.0	3415.0	**4**	50.0	14.8	9.2	139.6	57.4	2.3	12226	0.261
NT12406	1484	1275	3560	2106.3	2522.0	**24**	46.9	16.5	9.2	138.4	50.6	3.6	11828	0.266
NT12425	2701	1414	2984	2366.3	2842.5	**20**	49.5	16.7	9.2	140.6	55.5	4.0	13319	0.284
OVERLAN	1734	1659	2819	2070.7	2276.5	**29**	53.3	13.5	9.2	143.1	39.6	3.8	10929	0.279
NT06427	2965	2451	3482	2966.0	3223.5	**11**	45.9	15.6	8.9	138.8	48.1	1.6	12198	0.274
NE426GT	2297	2016	2759	2357.3	2528.0	**23**	48.0	15.2	8.8	139.1	51.0	3.0	13476	0.284
NT14430	1959	1635	2878	2157.3	2418.5	**26**	48.0	14.9	9.0	135.2	50.2	6.0	11281	0.313
NT14433	1773	1686	3046	2168.3	2409.5	**27**	50.3	16.2	9.3	139.4	60.1	3.3	13894	0.28
NT441	787	466	2732	1328.3	1759.5	**30**	45.1	15.3	9.4	147.0	59.0	3.1	10586	0.253
NT14407	3220	2293	3068	2860.3	3144.0	**13**	49.9	14.0	10.0	136.7	51.6	2.4	14370	0.294
NT15406	3949	2534	3108	3197.0	3528.5	**2**	50.6	14.0	9.1	134.7	51.0	2.2	13578	0.291
NT15410	2194	2225	3567	2662.0	2880.5	**18**	49.0	15.1	9.2	136.2	51.2	2.0	12771	0.272
NT15417	1827	2054	3882	2587.7	2854.5	**19**	48.1	15.6	9.0	138.4	52.5	1.7	12968	0.253
NT15419	2621	2660	3412	2897.7	3016.5	**15**	49.4	15.4	9.3	139.5	50.6	2.5	14124	0.276
NT15420	3173	1747	3065	2661.7	3119.0	**14**	48.6	15.1	9.0	139.8	53.5	1.5	11982	0.254
NT15424	2648	2492	2830	2656.7	2739.0	**22**	48.7	16.3	8.8	139.0	54.3	1.2	12696	0.271
NT15428	2792	1596	3705	2697.7	3248.5	**8**	48.9	14.9	9.9	135.2	47.8	3.0	12323	0.28
NT15429	2319	1796	4022	2712.3	3170.5	**12**	47.9	15.6	9.2	137.9	49.8	2.1	14692	0.271
NT15435	3105	1902	3525	2844.0	3315.0	**5**	48.5	15.7	9.1	140.2	54.7	2.1	12744	0.272
NT15440	3627	2684	2977	3096.0	3302.0	**6**	48.2	15.6	8.8	141.1	56.2	1.4	14209	0.261
NT15425	2068	1677	2916	2220.3	2492.0	**25**	49.2	15.5	9.2	138.7	56.9	1.6	14553	0.292
NT15421	3523	1953	2960	2812.0	3241.5	**9**	49.1	15.1	8.6	135.5	53.8	1.7	13686	0.312
Average	**2621.5**	**1930.2**	**3256.7**										**12971.3**	**0.28**
CV	**22.4**	**12.9**	**10.7**										**12.6**	**6.78**
LSD	**961.4**	**491.4**	**574.7**										**2295.1**	**0.03**

These trial results indicate that: 1. triticale produces more biomass and grain yield generally than wheat; 2. there is considerable GxE for forage yield; and 3. it very difficult to combine grain yield with forage yield. The comparison of triticale lines for forage was likely affected by different stages of harvest as seen by the different dry matter contents.

Of the lines tested in all the grain and forage trials, a few lines had good grain yield across the state, excellent forage yield in eastern NE. This highlights the need for testing our forage triticale lines in grain and forage trials across and beyond Nebraska.

The grain and forage data for 2015 are:

				Linc.	Mead.	**Grain**		**Bacterial**	Mead	**Mead**	Mead	Mead	Mead	Mead	Mead
	Winter	**Flowering**	**Height**	Yield	Yield	**Yield**	**Rank**	**Streak**	**Forage**	**Rank**	**IVDMD**	**NDF**	**ADF**	**ADL**	**Nitrogen**
	Survival	**Date**						**Avg.**	**Yield (dry)**	**Forage**					
Name	**%**	**D after 1.1**	**in**	(lbs/a)	(lbs/a)	**(lbs/a)**		**(1-9)**							
NT441	**100**	**151.5**	**63.7**	817	1424	**1121**	**29**	**2.4**	9774	**1**	68.43	66.47	40.01	5.76	2.10
NE03T416	**100**	**145.9**	**50.4**	2467	1642	**2055**	**10**	**1.4**	7800	**16**	64.87	67.71	40.74	5.82	1.75
NE422T	**95**	**153.8**	**66.4**	1175	746	**961**	**30**	**2.2**	7109	**21**	68.49	66.76	40.22	5.62	2.10
NT05421	**100**	**145.5**	**59.0**	1907	1727	**1817**	**16**	**2.7**	7819	**15**	66.43	66.30	39.23	5.70	1.89
NT06422	**100**	**143.7**	**53.9**	1635	1464	**1550**	**26**	**3.0**	7610	**18**	65.43	67.57	41.18	5.98	1.85
NT06427	**100**	**145.1**	**51.2**	1981	1430	**1706**	**19**	**2.9**	6852	**23**	64.08	68.08	41.74	6.00	1.64
NT07403	**100**	**142.8**	**49.0**	2091	1757	**1924**	**12**	**2.7**	7857	**14**	68.08	66.23	39.66	5.70	2.03
NT09404-1	**100**	**145.9**	**55.0**	2722	2283	**2503**	**1**	**2.2**	6360	**27**	65.95	66.42	40.07	5.87	1.76
NT09423	**99**	**146.1**	**51.6**	2156	2236	**2196**	**4**	**1.3**	8462	**9**	65.50	67.40	40.92	5.89	1.81
NT10417	**100**	**146.8**	**53.2**	2097	1644	**1871**	**13**	**2.7**	8421	**10**	66.60	66.93	39.78	5.90	1.97
NT10418	**95**	**143.6**	**58.9**	1718	1437	**1578**	**25**	**3.4**	6620	**24**	67.51	66.66	39.49	5.76	2.07
NT11406	**100**	**145.8**	**51.5**	2124	1598	**1861**	**14**	**2.5**	6569	**25**	64.62	67.95	41.15	5.90	1.81
NT11428	**100**	**146.3**	**56.6**	1893	1448	**1671**	**20**	**2.5**	7572	**19**	65.46	67.47	40.66	5.91	1.84
NT12403	**100**	**143.4**	**52.1**	2972	1969	**2471**	**2**	**2.5**	8524	**8**	66.00	67.76	40.84	5.90	1.84
NT12404	**96**	**143.8**	**51.7**	1949	2168	**2059**	**9**	**2.4**	7400	**20**	65.24	68.00	41.78	6.04	1.69
NT12406	**100**	**146.7**	**56.5**	1882	1713	**1798**	**18**	**3.2**	8852	**6**	66.27	66.08	39.93	5.76	1.69
NT12425	**100**	**144.5**	**56.9**	1568	1482	**1525**	**27**	**3.0**	9322	**3**	65.49	67.79	41.08	6.11	1.83
NT13416	**92**	**145.0**	**53.5**	2051	2240	**2146**	**7**	**1.9**	8411	**11**	65.38	68.10	41.66	6.11	1.67
NT13443	**100**	**145.2**	**61.1**	2476	2240	**2358**	**3**	**2.4**	7753	**17**	64.71	67.34	40.79	5.93	1.68
NT14407	**98**	**143.3**	**55.4**	2323	1807	**2065**	**8**	**2.7**	9643	**2**	63.87	68.77	41.65	5.97	1.64
NT14410	**98**	**143.7**	**54.1**	2628	1735	**2182**	**5**	**3.0**	7999	**13**	66.64	66.62	40.01	5.95	1.78
NT14426	**97**	**145.0**	**57.7**	1505	1833	**1669**	**21**	**3.2**	5686	**30**	65.65	67.28	40.64	6.03	1.84
NT14429	**98**	**144.3**	**53.1**	1635	1608	**1622**	**23**	**2.7**	8203	**12**	65.40	68.76	41.86	6.07	1.87
NT14430	**100**	**143.1**	**50.9**	1780	1932	**1856**	**15**	**3.5**	6899	**22**	66.28	65.59	39.61	5.87	1.75
NT14433	**98**	**145.9**	**62.6**	1788	1444	**1616**	**24**	**3.0**	8814	**7**	66.06	66.44	40.65	5.87	1.60
NT14434	**99**	**143.3**	**54.3**	1887	1380	**1634**	**22**	**3.5**	8933	**5**	64.79	68.26	41.97	6.13	1.87
NT14435	**99**	**144.0**	**52.0**	2317	1608	**1963**	**11**	**2.7**	6246	**28**	63.09	68.55	42.02	6.06	1.68
OVERLAND	**97**	**146.4**	**42.8**	1498	1171	**1335**	**28**	**3.9**	6241	**29**	65.71	67.46	40.86	6.01	1.86
NT09423-1	**99**	**147.8**	**52.6**	2421	1914	**2168**	**6**	**1.4**	6491	**26**	66.84	66.20	39.97	5.47	2.04
NE426GT	**100**	**146.2**	**53.3**	1916	1715	**1816**	**17**	**2.2**	8956	**4**	65.85	68.16	41.05	6.04	1.88
Average				**1979.2**	**1693.2**				7773		66	67	41	6	2
LSD				507.4	648.9				1626		2	2	2	0	0
CV				15.7	23.3				15		2	2	3	3	11

The 2016 Forage data from western NE (thanks to Dr. Dipak Santra) are:

Name	Forage	Height
	Yield	
	lbs/a	in
NE422T	4659	47.0
NE426GT	4921	42.8
NT441	6261	44.8
NT01451	6741	46.0
NT05421	6098	43.0
NT06422	4553	61.0
NT07403	5808	50.5
NT09423	5900	43.5
NT11406	5534	44.3
NT11428	5065	45.8
Average	**5553.9**	**46.9**
CV	**17.5**	**15.2**
LSD	**1415.3**	**10.3**

The 2015 Forage data from western NE (thanks to Dr. Dipak Santra) are:

2015	Dry Forage		Height	Mositure	Dry Matter
Sidney Forage	Yield	**Rank**			
Name	lbs/a		(in)	%	%
NE422T	7605	**1**	68.0	0.65	0.35
NT01451	7452	**2**	46.3	0.58	0.43
NT06427	7290	**3**	46.0	0.55	0.45
NT06422	6794	**4**	47.0	0.61	0.39
OVERLAND	5811	**5**	38.3	0.57	0.43
NT07403	5344	**6**	41.8	0.64	0.36
NT09423	5251	**7**	47.3	0.63	0.37
NT11428	5235	**8**	53.8	0.63	0.37
NT05421	4310	**9**	51.0	0.61	0.39
NT11406	3356	**10**	45.5	0.62	0.38
CV	29.2		4.0	8.8	13.4
GRAND MEAN	5844.8		48.5	0.6	0.4
Heritability	0.3		0.9	0.1	0.1
LSD	2473.2		2.8	0.1	0.1

The three-year (2015-2017) grain-yield data summary for locations where we were able to harvest trials is presented below:

	Grain	Grain	Grain	**State**	**Rank**	**State**	**State**
	Yield	Yield	Yield	**Avg Yield**		**Avg. Hdate**	**Avg. Height**
	(lbs/a)	(lbs/a)	(lbs/a)	**lbs/a**		**(d after**	**(in)**
	Mead	Linc.	Sidney			**Jan.1)**	
NE422T	1980	1546	2779	2121	**15**	138.3	52.2
NT05421	2709	2492	3067	2758	**8**	138.9	52.4
NT06422	2439	2394	3320	2694	**11**	138.2	51.2
NT06427	2694	2776	3425	2914	**5**	138.5	55.5
NT07403	2665	2878	3285	2831	**6**	141.0	54.4
NT09423	2180	2705	3611	2770	**7**	140.5	51.0
NT11428	2889	2447	3607	2933	**4**	143.3	60.9
NT12403	2677	2871	3752	2963	**3**	140.5	50.6
NT12406	2268	2215	3746	2704	**10**	138.9	55.1
NT12425-1	2673	2664	3652	2979	**2**	142.4	54.1
NT13416	2931	2728	3845	3124	**1**	137.3	46.2
NT14407	2732	2406	3278	2660	**12**	143.0	54.5
NT14433	1935	1976	2995	2198	**13**	140.1	55.5
NT441	1661	1115	2782	2152	**14**	137.5	51.3
OVERLAND	2577	1977	2973	2731	**9**	139.9	51.1

The three-year (2014-2016) grain and forageyield data summary for locations where we were able to harvest trials are presented below:

Name	Grain Yield (lbs/a) Mead	Grain Yield (lbs/a) Linc.	Grain Yield (lbs/a) Sidney	State Avg Yield lbs/a	Rank	Test Weight Lbs/bu	Prot	Moist	State Avg. Hdate (d after Jan.1)	State Avg. Height (in)	Bacterial Streak (1-9)	Winter Survival %	Forage Yield lbs/a	Forage Dry Matter	Forage RANK
NE422T	1451	1660	3143	1998	13	50.4	16.6	9.6	150.3	61.5	2.6	97.625	9468.0	0.219	12
NE426GT	2069	2173	3129	2368	11	48.0	15.2	8.8	144.1	49.7	3.6	99.55	11216.0	0.284	3
NT05421	2677	2473	3540	2859	3	49.9	15.7	9.3	143.3	55.3	2.9	99.575	11706.0	0.282	1
NT06422	2128	2255	3434	2528	8	46.3	15.3	8.7	142.2	51.3	3.5	99.55	10270.0	0.28	8
NT06427	2107	2582	3612	2641	7	45.9	15.6	8.9	143.6	48.1	2.5	99.75	9525.0	0.274	11
NT07403	2448	2827	3237	2759	5	48.8	14.2	9.1	139.7	47.0	3.4	99.6	10465.5	0.288	5
NT09423	2294	2564	3876	2790	4	48.1	15.6	9.6	144.9	49.4	1.8	99.625	10245.5	0.275	9
NT11428	2439	2440	3388	2718	6	50.0	14.8	9.2	144.8	55.2	2.7	100.025	9899.0	0.261	10
NT12403	2449	2914	4040	3070	2	49.8	14.5	9.3	141.6	48.8	4.2	100	10342.5	0.284	6
NT12406	1870	2104	3710	2487	9	46.9	16.5	9.2	143.8	51.3	4.4	99.65	10340.0	0.266	7
NT12425	2046	2159	3078	2414	10	49.5	16.7	9.2	144.2	54.7	3.3	99.925	11320.5	0.284	2
NT13416	2797	2479	3977	3084	1	50.5	14.6	9.5	142.7	51.9	3.3	95.85	10664.5	0.286	4
OVERLAND	1889	2403	3146	2347	12	53.3	13.5	9.2	146.3	46.2	3.7	97.95	8585.0	0.279	13
Aveage	2205	2387	3485	2620		49.0	15.3	9.2	144.0	51.6	3.2	99.1	10311.3	0.274	

It is clear that we have made progress in grain yields in triticale and that normally triticale has a higher grain yield than winter wheat. Marketing remains the major limitation to improving triticale's impact in modern agriculture.

10. Collaborative Research on Wheat Diseases

Dr. Stephen Wegulo, Department of Plant Pathology, and his staff continue to inoculate our experimental lines with wheat stem rust and Fusarium head blight (FHB, research funded by the U.S. Wheat and Barley Scab Initiative), and as time permits with wheat leaf rust. We continue to improve the greenhouse tests for stem rust. With the advent of the new race of stem rust, Ug99 (which can overcome some of the previously very durable resistance genes in wheat which were the main genes used in our program), we have greatly increased our efforts to introgress and pyramid new genes with our existing genes through the use of molecular markers.

Work continues on introgressing the resistance from *Agropyron* (*Wsm1*), but there appears to be a significant reduction in yield with the gene which may preclude its widespread use. The newer source for resistance/tolerance, *Wsm2*, developed by Scott Haley (CSU) in collaboration with KSU is also being introgressed. It seems to have less effect on agronomic performance, but also may not be as effective in Nebraska as *Wsm1*. Thanks go to Dr. Gary Hein, entomologist, who is testing them in the field. The frequency of lines carrying *Wsm1* resistance remains far lower than expected. With the continued spreading of wheat soilborne mosaic virus into our Lincoln fields (a key early generation testing site), we are now able to select for wheat soilborne mosaic virus resistant lines and many of lines have this beneficial trait.

11. The Effect of Fusarium Head Blight and Stripe Rust on Grain Yield of Hard Winter Wheat in Lincoln, NE. Javed Sidiqi, P.S. Baenziger, and S. N. Wegulo

To determine the effect of fungal plant pathogens on grain yield in eastern NE, we initiated a study in 2015 to compare fungicide treated and untreated plots using our elite nursery. While it is well documented that diseases reduce grain yield and fungicide use is becoming more common, growers still debate the cost and value of using fungicides. The purpose of this experiment was to provide growers with information on the value of fungicides so they can make informed decisions and also learn about our advanced breeding lines and how they respond to fungicides in the presence of disease. The Nebraska elite nursery contains 60 lines (two historic check cultivars, 6 cultivars, and 52 unreleased elite lines). Two fungicide regimens, treated vs. untreated, were utilized. In the treated plots, Cruiser Max®

was used to treat the seed before planting. Then at early spring green-up the plots were sprayed with Priaxor®. At flag leaf, the plots were sprayed with Twinline® followed by Caramba® at flowering. Seed treatments and fungicides were not applied to the untreated plots. Each fungicide treatment (treated and untreated) had 60 genotypes replicated twice in an alpha lattice design with an incomplete block size of 5 entries. Grain yield was harvested using a small plot combine and the grain was weighed after drying in the seed house. Eastern Nebraska receives on average 65 to 75 cm of rainfall annually. This study was completed in 2017 and is being written up for Javed's dissertation and for publication. Due to very high levels of moisture in 2015 and 2016, and considerably less moisture in 2017, the disease losses ranged from 44% in Lincoln 2015 to 15% at Lincoln 2017.

12. Fusarium Headblight (FHB) Breeding Research: F. Wang, S. Wegulo, G. Bai, P. S. Baenziger

In previous research, we found *Fhb1*, a major gene for scab (syn. Fusaium head blight) tolerance, was not pleiotropic or linked to genes that reduce grain yield. We are using high yielding *Fhb1* lines from segregating populations and Wesley *Fhb1 or* Overland *Fhb1* in our crossing block. For the first time, we are seeing lines in our multiple-location observation nursery that contain *Fhb1*, indicating our breeding strategy is beginning to work. The backcrossing approach is probably the best way to move needed genes into adapted line for further wheat improvement. Ms. Fang Wang will be working on the detached leaf assay (a high risk, but potentially very valuable approach to screening thousands of lines for FHB tolerance) and on using genomic selection for enhance FHB tolerance. We wish to thank the **U.S. Wheat and Barley Scab Initiative** for the continued funding to evaluate our lines for scab tolerance.

14. Selecting and Suppressing Triticale Cultivars for Organic No-till Rotations in Nebraska

R. Little, P. S. Baenziger,

Due to funding constraints, our organic research now emphasizes selecting triticale cultivar for organic no-till rotations. The need for this research is that tilling soil reduces organic matter and can increase soil erosion. No-till organic rotations often involve crimping a cover crop and then seeding your organic crop of interest. In this research we were interested in determine if triticale genotypes differed in their ability to be crimped proir to the land being planted to soybeans. NT15471 performed well in this rotation, but additional data will need to be collected. Nt15471 was increased at Yuma AZ and will be shared using a test only material transfer agreement with organic researchers.

15. Prospects for Selecting Wheat with Decreased Cadmium Concentration in Grain: C. Liu, M. Guttieri, P.S. Baenziger, D. Rose, and B. Waters

Wheat (*Triticum aestivum* L.) is a primary staple cereal and a significant source of mineral nutrients in human diets. Therefore, decreasing concentration of the toxic mineral, cadmium (Cd), could significantly improve human health. Previously we found, grain Cd concentration of some genotypes grown in Nebraska trials were above the Cd Codex guidance level (> 0.2 mg kg-1), and highly repeatable differences in grain Cd were found between pairs of low and moderate-Cd commercial cultivars. Grain Cd concentration was predicted by Cd concentration in aboveground plant tissues at anthesis. Genome-wide association scans using high density SNP markers identified markers on 5AL associated with grain Cd in a region homoeologous to the Cdu1 locus on 5BL in durum wheat (*Triticum turgidum* L. var. durum Desf.). Our current work is to study the uptake of Cd, and ways to select for lower Cd.

The selection of low-Cd genotypes at maturity should be the simplest and most accurate selection strategy (only use grain Cd concentration, and its apparent error rate (APER) was 0) compared with the selection at other stages. However, if the breeder wants to do the selection before grain maturity and have enough time for data analysis and the selection of other traits, selection at 3 WAA could be a good choice. The selection at 3 WAA used Cd concentration of seeds and terminal node and gave the second lowest APER of 0.036. This means that breeders would expect 36 misclassifications in every 1000 lines tested. In sum, the rank of selection accuracy from high to low was maturity > 3WAA > 4WAA > 5WAA. The rank of labor and cost from high to low was 4WAA > 3WAA > 5WAA = maturity. However, our study only used data from four genotypes and two years. More data from a larger population and multiple locations are needed for a better estimation of the APER.

From 2014 to 2016, we built a $F_{4:7}$ population of Wesley x Panhandle (105 lines). We compared two selection strategies (hydroponic based selection vs. KASP marker selection). Both selection strategies work, but the KASP marker selection is easier and more reliable. However, ofr the very best low Cd lines, it may be best to use KASP markers in the early generations to fix the low Cd accumulation allele followed by genomic selection to further reduce Cd in grain. We are building a $F_{6:7}$ population of Wesley x Panhandle by single seed decent as an additional more homogeneous population of lines.

16. **Hybrid Wheat:** N. Garst, A. Easterly, H. Donoho, S. Blecha, Y. Delen, S. Palai-Delen, P.S. Baenziger, A. Ibrahim (Texas A&M University), J. Rudd (Texas A&M University), and Bhoja Basnet (CIMMYT) Saaten-Union Recherche in France, Jochen Reif (the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany), and Friedrich Longin (University of Hohenheim in Germany)

One of the great opportunities and challenges for wheat improvement is the development of hybrid wheat. Currently numerous companies have hybrid wheat breeding efforts with Saaten-Union Recherche being one of a few companies that markets hybrid wheat. Our belief is that the public sector needs to have a public, transparent hybrid wheat breeding effort to advance the science and educate the next generation of plant breeders. We have been working on hybrid wheat for the past 5 years. As of January 2018, our efforts on developing a public, transparent hybrid wheat platform took a major step forward with the successful receipt of a NIFA-IWYP grant for hybrid wheat development. The University of Nebraska will be the lead institution and will work closely with Texas A & M University, Kansas State University, Saaten-Union Recherche in France, the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany led by Jochen Reif, and the University of Hohenheim in Germany led by Friedrich Longin. This grant is for 3-years and will support additional testing of hybrids as well as fund research into some of the key questions regarding hybrid wheat production. In this research we have 4 main objectives.

Objective 1: Screen two large wheat breeding programs for the floral and plant traits needed for efficient hybrid seed production and performance.

This objective directly relates to the need to have a viable hybrid wheat production system that enhances cross pollination. The expected outcome will be to identify lines with excellent male and female floral characteristics including response to the CHA and in CMS backgrounds

At UNL, we have continued to screen our advanced breeding materials for anther extrusion.

Previously, we screened the preliminary, advanced, and elite yield trials, as well as the regional performance nursery for a total of 288 lines in the field for the second year. The anther extrusion ranged from 2 to 7 (on a scale where one indicated that few anthers, or only the tip of most anthers are visible outside of the glumes at anthesis, and nine indicating that many anthers were fully exposed outside of the florets at anthesis) in the field, but there was considerable genotype by environment (GxE) interactions. Over fifty percent of the lines had scores of 5 or above. A score of 5 is considered to be adequate to be a male line in hybrid production. Hence, we have numerous lines that should be suitable as pollinators. While some lines (e.g. Freeman, scored as 7) consistently had high values for anther extrusion and other lines consistently had poor anther extrusion (e.g. Camelot scored as 2), many lines exhibited higher environmental variability. Hence to identify excellent pollinator lines, we will need to identify lines like Freeman that are environmentally stable. The broad sense heritability for anther extrusion was relatively high (ranging from 0.62 to 0.85 depending upon the nursery). In 2017 we screened an additional 120 lines and 299 lines the Hard Winter Wheat Association Mapping Panel (HWWAMP) developed as a resource for the Great Plains by the previous TCAP grant. The HWWAMP will be used in genome wide association studies to map QTLs for anther extrusion. As part of our chemical hybridizing agent (CHA) crossing block, we have noticed that the highest yielding crossing blocks are those where the delay between the male and female lines is good and the male is an excellent pollinator. For example, hybrid seed production is consistently good when Freeman was used as a pollinator. Working with our German cooperators who identified two excellent anther extrusion lines for Europe, we requested seed from their owners and began crossing them to our elite lines to enhance anther extrusion At TAMU,we have screened wheat breeding nurseries (SOBS, AOBS, STP1-STP4, and AP1-AP10) for floral characteristics in spring 2014, and 100 promising lines were selected and planted at College Station during fall 2014. A set of promising 180 TAM germplasm lines, selected for floral characteristics, was planted in the field at College Station and McGregor in fall 2016 (representing STP 1 – 4, TXE, UVT) to look at genotype-by-environment interaction for anther extrusion and female stigma exertion and gape.

To better understand our CHA hybrid system and also to develop the cytoplasm male sterile system (CMS) using the *Triticum timopheevi* cytoplasm, we planted seven backcross-5 alloplasmic lines (e.g. lines with an elite wheat line nucleus and the *timopheevi* cytoplasm, which should be sterile) with sufficient seed to plant a plot. These plots were surrounded by a mixture of herbicide tolerant males that differed for anthesis date with the idea that we can harvest and plant the F_1 seed. By spraying the F_1 plants which will be heterozygous at two herbicide tolerant loci, we should be able to kill any selfs or outcrosses to herbicide sensitive lines. Seed production on the cms females was excellent (ranged from 918 g/plot to 2132 g/plot).

Texas:

3.2. Objective 2: Create and test hybrids to establish and confirm initial heterotic pools in wheat. All heterotic pool development begins with creating and testing hybrids.

The expected outcome is to gain a better understanding on how best to use Croisor® 100, determine the level of heterosis currently available in hexaploid hard winter wheat, and identify parental lines for future heterotic groups.

Nebraska and Texas: We used Croisor® 100 make hybrids from a 25 female x 25 male complete diallel. For efficient field work, an additional female line was added making the crossing block 25 males by 26 females (hereafter referred to as a 25 x 25 diallel plus one). Visual ratings for CHA induced floral gaping and phytotoxicity due to CHA application was recorded. Few heads in every female plot were bagged to estimate the efficacy of the CHA. Ideally, the bagged heads were completely sterile indicating that the CHA worked, and the seed set on the unbagged heads was good indicating that there is good cross-pollination and no phytotoxic effects. The female plots were harvested to measure grain yield. In 2015, 80% of bagged heads in the females had 10 seeds or fewer, whereas 93% had 5 seeds or fewer in 2016, so adequate sterility was achieved for our hybrid seed production. We completed our first year of hybrid evaluation trials in 2016 (three locations in NE and one in TX) and our second year (three locations in NE and two in TX) in 2017. An augmented incomplete block design was used as hybrid seed is precious and the trials are very large (complete replications would be impossible). Due to limited seed, not every hybrid was tested at every location. However, at least 550 hybrids were tested at the five locations in 2017. Complete sets of the diallel crosses (650 hybrids) were planted at two locations in Nebraska, in Lincoln and at North Platte. We are now working on analyzing the data, removing the spatial variation, comparing reciprocal crosses, and estimating heritability and heterosis.

We successfully used the balanced missing design pioneered by our German cooperators for the 2017 crossing block. In this crossing block, we had 50 males and 100 females (total of 150 lines with 25 males and 50 females selected by both UNL and TAMU) where each male was crossed to 14 females. All of the lines have be genotyped by sequencing (GBS). To ensure that environmental hazards did not destroy the crossing block, we grew three crossing blocks (1 in NE and 2 in TX). The NE (25 males and 100 females) and one of the TX (the remaining 25 males and the same 100 females) crossing blocks worked very well with a range of seed produced from 65g to 2070g with an average of 657g in Lincoln and 24g to 1182g with an average 326g in Texas. By splitting the crossing blocks, we lessened the potentially catastrophic loss of losing the crossing block. However, we discovered that the flowering times in TX are considerably wider than at Lincoln, making it harder to estimate the anthesis to exposed stigma ”nicking” period when crosses should be most successful. The last crossing block in TX was less successful probably due to weather shortly after CHA application. The seed from both crossing blocks has been sent to Lincoln for designing the hybrid yield trials for six locations (three in Nebraska and three in Texas). Note that roughly 210 g of seed are need for the six trials, so many of the hybrids have sufficient seed for two years or more of testing. We also had a small experiment to study CHA rates and different adjuvants to reduce phytoxicity and the amount of chemical needed to sterilize wheat plants.

3.3. Objective 3: Genotype the lines going into the heterotic pools and improve algorithms to separate lines into maximum likelihood pools for future testing and validation.

With the advances in genomics and genomic predictions, we will be able to estimate many more hybrid combinations than we can test which greatly improves the efficiency of heterotic pool development. The expected outcome is to determine lines with the best male and female floral characteristics and assignment to respective heterotic pools to improve heterosis and hybrid seed production efficiency in hexaploid wheat. We will have to wait until the hybrid yield trials are conducted in 2018 and 2019 to start working on developing the heterotic groups and patterns. The work that has been accomplished so far related to this objective is described in detail here:

DNA isolation, genotyping-by-sequencing, SNP calls: Five seeds of each of the 150 lines in the crossing block were grown in the University of Nebraska-Lincoln (UNL) greenhouse and young leaves were bulked and harvested from 2-week old seedlings in 96-well plates. DNA was extracted using BioSprint® 96 DNA Plant Kit from QIAGEN per the manufacturer's protocol. The genotyping-by-sequencing (GBS) was performed at Wheat Genetics and Germplasm Improvement Laboratory (WGGIL) at Kansas State University. The quality inspection of sequence files was performed using FASTQC. SNP calling was carried out using TASSEL V5.2.37 and the International Wheat Genome Sequencing Consortium (IWGSC) Reference Sequence v1.0 (released on January 14, 2017) of the bread wheat variety Chinese spring was used as the reference genome for SNP calling. The GBS data of 150 parental lines was analyzed along with an additional 6,978 lines belonging to the Nebraska breeding program for getting a better coverage of the genome, increasing read depth, and for inspecting SNP calling accuracy.

We identified 280,285 SNPs across all of the 7,128 samples. Subsetting the SNP calls for the 150 parental lines and filtering SNPs and lines with appropriate quality control (excluded SNPs and lines with >20% missing information and SNPs with minor allele frequency (MAF) <0.05) resulted in 143 lines and 39,960 high-quality SNPs. This dataset filtered with high-stringency was then used to investigation population structure of the parental lines. Seven parental lines with more than 20% missing information will be re-genotyped using GBS in 2017-2018.

Building hybrids (*in silico*): The 280,285 SNPs obtained in the SNP calling were filtered to retain high-quality SNPs and the missing sites were imputed using Beagle v4.1. The parental lines were subdivided and SNPs with MAF>0.05 were retained. This resulted in 114,436 SNPs across 150 lines. Subsequently, we built 11,175 hybrids *in silico* using *CreateHybridGenotypesPlugin* in TASSEL. If either one of the parents has a heterozygous genotype at a given locus, then the hybrid genotype at that locus will be marked missing in the hybrids. This resulted in missing sites in the hybrids. The hybrid dataset was filtered for retaining SNPs with MAF>0.05 and maximum missing sites less than 20%, which resulted in 56,719 high-quality SNPs across the hybrids. This indicates, we will very likely have more than 50K SNPs across the 11,175 hybrids to run the prediction in 2018-2019. For investigating the population, we added an additional filter and excluded hybrids with >20% missing sites. This resulted in 56,470 high-quality SNPs across 10,731 hybrids for the population structure analysis in the hybrids.

Population structure of the parents and hybrids: The population structure was investigated using principal component analysis (PCA) and a phylogeny based on Neighbor joining (NJ) algorithm (results from the NJ phylogeny are not discussed in this report). The structure was visualized using three plots: (1) a plot of PC1 versus PC2 with line names presented in a non-overlapping manner; (2) a plot of PC1 versus PC2 using hexagonal binning that reveals the patterns in the population; (3) A parallel coordinate plot to visualize the information from PC1 to PC5. The plots are provided in a separate PDF file (with filename PopulationStructure_ParentsAnd Hybrids.pdf). The inferences from the structure analysis of parents and hybrids are as follows:

Parents:

- Parental lines are quite diverse based on PCA.
- There are two outgroups, one comprising five lines from the Nebraska (NE) breeding program and the other containing five lines from the Texas (TX) program (list of the lines is provided at the end).
- Among the rest of the lines, we see three groups weakly structured. One comprising mainly lines from NE and the other from TX, and the third one comprising lines both from NE and TX. This is also true in the NJ phylogeny (result not shown in the attached PDF)
- Predicting the performance of (*in silico*) hybrids generated by making crosses among the parental lines in the outgroups can be difficult due to the lack of kinship with the rest of the

parental lines. We will follow up with these lines and take a closer look at their pedigree to verify the observations. It may be difficult to predict the performance of the hybrids derived from these lines in the outgroup. But, a diverse training dataset will be better for the predictions.

- NE outgroup contains five lines: LCI13NEDH_14_53, PSB13NEDH_14_71W, PSB13NEDH_14_83W, PSB13NEDH_15_58W, WESLEY. Except WESLEY, rest of the lines are doubled haploid lines involving Nebraska and South Dakota parents.
- TX outgroup and outliers: Six TX lines cluster separately from the rest of the lines - TX11A001295, TX11A001295_AZ333, TX11A001295_AZ348, TX12A001638, and TX14M7034, and TX14M7174 – We will follow-up with our collaborators in Texas and take a closer look at the pedigree of these lines to verify this information.

Hybrids:

- Structure among the hybrids is similar to the parents but with a significantly higher overlap/increased kinship.
- Weakly structured parental groups containing NE, TX, and NE/TX lines are replaced by NExTX, TXxNE, and NExNE/NExTX/TXxTX. Higher kinship by creating the hybrids (visually apparent in the hexagonal binning plot) should substantially assist with increasing prediction accuracy.
- A few hybrids (NExNE and TXxTX crosses) cluster separately from the rest as outliers/outgroups. These may be beneficial for the training data but predicting their performance accurately will likely be challenging.
- The list of hybrids that form an outgroup are derived from the NE and TX parents that clustered as outgroups (with the exception of TAM112)
- List of hybrids in the outgroup (and the parents) are listed here: TX11A001295/TX12A001638, TX11A001295/TX11A001295_AZ333, TX11A001295_AZ333/TX12A001638, TX11A001295/TX11A001295_AZ348, TX11A001295_AZ348/TX12A001638, TX11A001295_AZ333/TX11A001295_AZ348, TAM112/TX12A001638, TAM112/TX11A001295, TAM112/TX11A001295_AZ333, TAM112/TX11A001295_AZ348 --- **Parents**: TX11A001295, TX12A001638, TX11A001295_AZ333, TX11A001295_AZ348, TAM112

LCI13NEDH_14_53/PSB13NEDH_15_58W, PSB13NEDH_14_83W/PSB13NEDH_15_58W, LCI13NEDH_14_53/PSB13NEDH_14_83W, PSB13NEDH_15_58W/WESLEY, LCI13NEDH_14_53/WESLEY, PSB13NEDH_14_83W/WESLEY, PSB13NEDH_14_71W/PSB13NEDH_15_58W, LCI13NEDH_14_53/PSB13NEDH_14_71W, PSB13NEDH_14_71W/PSB13NEDH_14_83W, PSB13NEDH_14_71W/WESLEY – **Parents**: LCI13NEDH_14_53, PSB13NEDH_15_58W, PSB13NEDH_14_83W, WESLEY, PSB13NEDH_14_71W

3.4. Objective 4: Map restorer genes in *T. timopheevi* cytoplasm and create a series of CMS tester lines, their maintainer lines, and a series of elite restorer lines (R-lines) and begin to determine the efficacy of CMS-based hybrid systems.

Cytoplasmic male sterility is one of the two most commonly used wheat hybrid production systems, so it must be explored and improved. The expected outcomes will be to identify and tag R-genes for the *T. timopheevi* male sterile cytoplasm, the effect of CHA on different male sterile cytoplasms with restorer genes, new R-lines for the *T. timopheevi* cytoplasm, and a random mating population in the

T. timopheevi cytoplasm.

CIMMYT and Texas: A BC_1F_1 mapping population of spring wheat genotypes (n = 280) was developed by crossing a restorer source (*T. timopheevii* cytoplasm) with an advanced line (*T. aestivum* cytoplasm) at El Batan, CIMMYT. In 2016-17 growing cycle, the BC_1F_1 population was phenotyped for fertility restoration by counting the number of fertile lateral florets and total number of seeds per spike present in a set of three spikes per genotype. The spikes were covered with glassine bags before flowering to prevent cross fertilization and contamination. The individual BC_1F_1 plants have also been genotyped using a 20K SNP chip. The genotypic data will be filtered for monomorphic markers and missing data and will be used to map regions corresponding to fertility restoration. Software package ICIMapping (Integrated Breeding Platform, https://www.integratedbreeding.net/) will be initially used to map genomic regions corresponding to fertility restoration using simple interval mapping and inclusive composite interval mapping (ICIM) algorithm. We expect to have preliminary mapping results by the end of 2017.

17. Enhancing wheat (*Triticum aestivum* L.) drought tolerance using SNP markers based on high throughput genotyping by sequencing technology: Waseem Hussain, P. Stephen Baenziger, Vikas Belamkar, Mary Guttieri, Amanda Easterly, Jorge Venegas and Jesse Poland

Winter wheat parents 'Harry' (drought tolerant) and 'Wesley' (drought susceptible) were used to develop a recombinant inbred population with future goals of identifying genomic regions associated with drought tolerance. To precisely map genomic regions, high-density linkage maps are a prerequisite. In this study genotyping-by- sequencing (GBS) was used to construct the high-density linkage map. The map contained 3,641 markers distributed on 21 chromosomes and spanned 1,959 cM with an average distance of 1.8 cM between markers. The constructed linkage map revealed strong collinearity in marker order across 21 chromosomes with POPSEQ-v2.0, which was based on a high-density linkage map. The reliability of the linkage map for QTL mapping was demonstrated by co-localizing the genes to previously mapped genomic regions for two highly heritable traits, chaff color, and leaf cuticular wax. Applicability of linkage map for QTL mapping of three quantitative traits, flag leaf length, width, and area, identified 21 QTLs in four environments, and QTL expression varied across the environments. Two major stable QTL, one each for flag leaf length (*Qfll.hww-7A*) and flag leaf width (*Qflw.hww-5A*) were identified. The map constructed will facilitate QTL and fine mapping of quantitative traits, map-based cloning, comparative mapping, and in marker-assisted wheat breeding endeavors. Additional research is ongoing.

18. Translating genomic research into cultivar development in the Nebraska wheat program:

A. Bioinformatics, statistics and quantitative genetics analyses for assisting with selections, advancements and parental selections in the winter wheat breeding program.

Vikas Belamkar, Mary J. Guttieri, Sarah Blecha, Nicholas Garst, Jesse Poland, P. Stephen Baenziger

We continued to advance the use of genomic research in the wheat breeding program and evaluated the performance of genomic research conducted in previous years. Briefly, here are the key points from our efforts in 2017:

Built a new SNP calling framework using the revamped version of the software TASSEL 5v2. Processed genotyping-by-sequencing (GBS) data of ~17,076 samples, ~7,128 unique breeding lines, and identified over 280,285 variants. Marker-trait analysis including genome-wide association studies (GWAS) and genomic selection (GS) were performed, and the results generated were utilized to aid in selection and advancement of lines from $F_{3:5}$ and $F_{3:6}$ nurseries.

The $F_{3:5}$ nursery was hit by a hail storm in 2016 and yield data of nearly half the nursery (~1,000 lines) was in accurate. GS helped recover lines from this set and lines were advanced to the 2017 $F_{3:6}$ nursery. The selection of 2017 $F_{3:6}$ nursery are now complete and lines are selected and advanced to the 2018 $F_{3:7}$ nursery. This has allowed to follow-up and evaluate the performance of GS when selections were made in 2016. We are happy to report that of the 53 lines advanced from 2017 to 2018, 35 lines were from less hail-damaged plots, and the remaining 18 came from hail damaged plots. We believe GS and the method of applying GS was successful in recovering lines lost due to hail damage.

The breeding program continued to use both genomic estimated breeding values (GEBV) and phenotypic values (BLUP) to make selections accurately in $F_{3:5}$ and $F_{3:6}$ trials.

Nearly 10 lines with exceptional genetics based on high-GEBV and high-BLUP were retrieved from the $F_{3:6}$ nursery grown in 2017 and added to the 2018 crossing block as parents. By using lines from the $F_{3:7}$ nursery and not waiting until $F_{3:8}$ or $F_{3:9}$ to test the performance, saved a year or two, in the breeding program.

B. Genomic selection research in the winter wheat breeding program

Vikas Belamkar, Mary J. Guttieri, Ibrahim El-basyoni, Waseem Hussain, Diego Jarquín, Nicholas Garst, MengYuan Wang, Amanda Easterly, Sarah Blecha, Jesse Poland, Aaron Lorenz, P. Stephen Baenziger

Genomic prediction (GP) is now routinely performed in crop plants to predict unobserved phenotypes. The use of predicted phenotypes to make selections is an active area of research. Here, we evaluate GP for predicting grain yield and compare genomic and phenotypic selection by tracking lines advanced. We examined four independent nurseries of $F_{3:6}$ and $F_{3:7}$ lines trialed at 6 to 10 locations each year. Yield was analyzed using mixed models that accounted for experimental design and spatial variations. Genotype-by-sequencing provided nearly 27,000 high-quality SNPs. Average genomic predictive ability (PA; Pearson's correlation coefficient), estimated for each year, by randomly masking lines as missing in steps of 10% from 10% to 90%, and using the remaining lines from the same year as well as lines from other years in a training set, ranged from 0.23 to 0.55. The PA estimated for a new year using the other years ranged from 0.17 to 0.28. Further, we tracked lines advanced based on phenotype from each of the four $F_{3:6}$ nurseries. Lines with both above average genomic estimated breeding value (GEBV) and phenotypic value (BLUP) were retained for more years as compared to lines with either above average GEBV or BLUP alone. The number of lines selected for advancement was substantially greater when predictions were made for 50% of the lines in each year. Hence, evaluation of only 50% of the lines yearly seems possible. This study provides insights to assess and integrate genomic selection in breeding programs of autogamous crops.

19. Broadening the Genetic Base of Wheat Using Primary Synthetic Wheat:

Madhav Bhatta, P. Stephen Baenziger, and Alexey Morgounov (CIMMYT-Turkey)

Synthetic hexaploid wheat (SHW) is a reconstitution of hexaploid wheat from its progenitors (*Triticum turgidum* ssp. *durum* L.; AABB x *Aegilops tauschii* Coss.; DD) and has novel sources of genetic diversity for broadening the genetic base of elite bread wheat (BW) germplasm (*T. aestivum* L). Understanding the diversity and population structure of SHWs will facilitate their use in wheat breeding programs. Our objectives were to understand the genetic diversity and population structure of SHW panel and compare the genetic diversity of SHWs with elite BW cultivars and demonstrate the potential of SHWs to broaden the genetic base of modern wheat germplasm.

The genotyping-by-sequencing of SHW provided 35,939 high-quality single nucleotide polymorphisms (SNPs) that were distributed across the A (33%), B (36%), and D (31%) genomes. The percentage of SNPs on the D genome was nearly same as the other two genomes, unlike in BW cultivars where the D genome polymorphism is generally much lower than the A and B genomes. This indicates the presence of high variation in the D genome in the SHWs. The D genome gene diversity of SHWs was 91.5% higher than that found in a sample of elite BW cultivars. Population structure analysis revealed that SHWs could be separated into two subgroups, mainly differentiated by geographical location of durum parents and growth habit of the crop (spring and winter type). Further population structure analysis of durum and *Ae.* parents separately identified two subgroups, mainly based on type of parents used. Although *Ae. tauschii* parents were divided into two sub-species: *Ae. tauschii ssp. tauschii* and *ssp. strangulate,* they were not clearly distinguished in the diversity analysis outcome. Population differentiation between SHWs (Spring_SHW and Winter_SHW) samples using analysis of molecular variance indicated 17.43% of genetic variance between populations and the remainder within populations.

SHWs were diverse and had a clearly distinguished population structure identified through GBS-derived SNPs. The results of this study will provide valuable information for wheat genetic improvement through inclusion of novel genetic variation and is a prerequisite for association mapping and genomic selection to unravel economically important marker-trait associations and for cultivar development.

20. Genome wide association study (GWAS) and breeding for common bunt and stem rust resistance in Nebraska winter wheat

Amira Mourad, Ahmed Sallam, Vikas Belamkar, Stephen Wegulo, Jesse Poland, Robert Bowden, Guihua Bai, Ezzat Mahdy, Bahy Raghib, Atif Abo El-Wafaa, Yue Jin and P. Stephen Baenziger

A. Stem rust resistance in winter Nebraska wheat:

Stem rust (caused by *Puccinia graminis* f. sp. *tritici* Eriks. & E. Henn.) is a major disease in wheat (*Triticum aesitvum* L.). However, in recent years it occurs rarely in Nebraska due to weather, the lack of inoculum, and the effective selection and gene pyramiding of resistance genes. To understand the genetic basis of stem rust resistance in Nebraska winter wheat, stem rust seedling resistance was evaluated in two Nebraska winter wheat nurseries with a total number of 330 genotypes for up to eleven stem rust races in one nursery and to the Nebraska common race, QFCSC in the other nursery. The two nurseries were genotyped for four stem rust genes (Sr31, SrAmigo, Sr24, and Sr38) at USDA-AR. Based on the genotyping data, pedigree and the phenotyping data, the two nurseries were postulated to contain five more resistance genes; Sr6, Sr36, SrTmp, Sr30, and Sr9e. To corroborate the presence of these genes, specific SSR markers were used. Out of the 330-tested genotyped, three genotypes contained markers for five stem rust resistance genes and had a very high resistance level against a wide range of stem rust races. In both nurseries, the highest percent of genotypes contained markers for *Sr6.* Genome-wide association study for stem rust resistance identified 32 SNP markers, which were significantly (Bonferroni corrected $P < 0.05$) associated with the resistance on chromosome 2D. A highly significant linkage disequilibrium (LD, r2) was found between the significant SNPs and the specific SSR marker for the Sr6 gene (Xcfd43). This suggests the significant SNP markers are tagging Sr6 gene. Out of the 32 significant SNPs, eight SNPs were in six genes that are annotated as being linked to disease resistance in the IWGSC RefSeq v1.0. The 32 significant SNP markers were located in nine haplotype blocks. SNP markers identified in this study can be used in marker-assisted selection, genomic selection, and to develop KASP (Kompetitive Allele Specific PCR) marker for the Sr6 gene.

B. Common bunt resistance in winter wheat:

Common bunt (caused by *Tilletia caries* and *T. foetida*) has been considered as a major disease in wheat following rust. Despite that it can be easily controlled using seed treatment with fungicides, fungicides often can or are not be used in organic and low-input fields. Planting common bunt resistant genotypes is a alternative. To identify resistance genes for Nebraska common bunt race, the global set of differential lines were inoculated, and nine genes were found to be resistant to this race. To understand the genetic bases of the resistance in Nebraska winter wheat a set of 330 genotypes were inoculated and evaluated under field conditions in two locations. A set of 62 genotypes had different degrees of resistance. Using genome-wide association study, a set of 123 SNPs located on fourteen chromosomes were identified to be associated with the resistance. Different degrees of linkage disequilibrium was found between the significant SNPs, indicating the presence of many minor QTLs controlling the resistance. Based on the chromosomal location of some of the known genes, some of the SNPs are expected to be associated with *Bt1*, *Bt6*, *Bt11* and *Bt12* resistance loci. The remaining significant SNPs are associated with unknown genes or known genes with an unknown locations. Common bunt resistance seems to be an independent trait as no correlation was found between it and chlorophyll content, days to heading and plant height.

21. Genetic and Molecular Dissection of Drought tolerance in winter wheat (*Triticum aestivum* L.) using QTL mapping.

Ahmed Sallam, Vikas Belamkar, Wassem Hussain, P. Stephen Baenziger

The genetic architecture of seedling drought tolerance is complex and needs to be better understood. To address this challenge, a population of 147 recombinant inbred lines (F_9) derived from crossing between a wheat cultivar, ‘Harry’ (seedling drought tolerant) and ‘Wesley’ (seedling drought susceptible) was used to study the genetic variation for seedling drought tolerance and identify genomic regions associated with seedling drought tolerance in winter wheat. At the seedling stage, all genotypes were sown in three replications with a randomized complete block design under controlled conditions in a greenhouse. Seven traits were scored and grouped into tolerance traits (days to wilting, wilting score, and stay green) and survival traits (days to regrowth, regrowth, drought survival rate, and recovery after drought). Three selection indices were calculated (1) tolerance index, (2) survival index, and (3) drought tolerance index (DTI). A high genetic variation was found between all genotypes for all seedling traits scored in this study. No or weak significant correlations were found between tolerance and survival traits. The heritability estimates ranged from 0.53 to 0.88. Drought tolerance index had high significant phenotypic and genotypic correlations with all seedling traits scored in this study. Moreover, the same set of lines was tested in two dry locations Grant and Sidney at Nebraska State for two successive seasons 2015 and 2016. In both locations, the yield per plot was measured to identify genotypes having the highest grain yield. All genotypes for each seedling trait were sorted according to their drought tolerance and for grain yield. The best 15 genotypes in each trait were selected. One genotype HW_121 was found to be among the best 15 genotypes in eight seedling traits and had the highest grain yield in the two locations in seasons 2016 and 2017.

The preliminary QTL analysis revealed 11 QTL associated with drought tolerance. Two QTLs had a pleotropic effect. No common QTL was found to include any of survival traits and tolerance traits. Most of QTL were located in chromosome 4A. We concluded the tolerance and survival traits are controlled by different genes. By looking to the genome of HW_121, the highest drought tolerant and high yielding genotype, we found that this genotype inherited eight QTL from Harry and three from Wesley. Interestingly, the two parents were screened for *DrebB1* and *fehw3* genes using Kompetitive Allelic Specific PCR (KASP). Harry genotype possessed the two genes, which, Wesley did not have the two genes.

In conclusion, the protocol that was used to apply drought tolerance included two types of important traits. we identified genotypes having a combination of high drought tolerance, at seedling stage, and high grain yield in dry environments. Moreover, the QTL mapping results confirmed the high level of drought tolerance of the selected genotypes. These genotypes could be used for further breeding program to improve winter Nebraska wheat. The next steps of this research will be continued by testing the whole population for two KASP genes.

22. **Genetic diversity and population structure of $F_{3:6}$ Nebraska winter wheat (*Triticum aestivum* L.) Genotypes Using Genotyping-By-Sequencing**

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The availability of information on the genetic diversity and population structure in wheat (*Triticum aestivum* L.) breeding lines will help wheat breeders to better use their genetic resources and manage genetic variation in their breeding program. The recent advances in sequencing technology provide the opportunity to identify tens or hundreds of thousands of SNPs in large genome species (e.g. wheat). These SNPs can be utilized for understanding genetic diversity and performing genome wide association studies (GWAS) for complex traits. In this study, the genetic diversity and population structure was investigated in a set of 230 genotypes ($F_{3:6}$) derived from various crosses as a prerequisite for GWAS and genomic selection. Genotyping-by-sequencing provided 25,567 high-quality SNPs. The genetic diversity and polymorphism information content (PIC) values across chromosomes varied from 0.09 to 0.37 with an average of 0.23. The distribution of SNP markers on the 21 chromosomes ranged from 319 on chromosome 3D to 2,370 on chromosome 3B. The analysis of population structure revealed three subpopulations (G1, G2, and G3). Analysis of molecular variance identified 8% variance among populations and 92% within populations. Of the three subpopulations, G2 had the highest level of genetic diversity based on three genetic diversity indices: Shannon’s information index (I) = 0.494, diversity index (h) = 0.328 and unbiased diversity index (uh) = 0.331, while G3 had lowest level of genetic diversity (I = 0.348, h = 0.226 and uh= 0.236). This high genetic diversity identified among the subpopulations can be used to develop new wheat cultivars.

V. GREENHOUSE RESEARCH

Since 2012, the majority of F_1 wheat populations were grown at Yuma, AZ. Mainly populations needing additional crosses are being grown in the Lincoln Greenhouses. This change reduced our greenhouse space and greenhouse labor, and provided much greater quantities of F_2 seed. We made more than 100 triticale, 100 barley and 1000 wheat crosses in last year’s fall, winter, and spring greenhouses.

VI. PROPRIETARY RESEARCH

Public Private (University of Nebraska) Collaborations:

In 2009, the University of Nebraska decided to sustain the wheat-breeding project via enhanced collaborations with commercial companies spanning the value chain. The University of Nebraska-Lincoln (UNL) has had a long-standing arrangement with BASF, providing access to the Clearfield technology. Infinity CL and Settler CL are outcomes of this research. We have one lead 2-gene line, NHH144913-3 that was approved by BASF for commercial release. We are getting one additional year of data before we make the formal release. However, it is our full intention based on previous data that the line will be released. We continue our collaboration with Ardent Mills who support our McCook Nursery and provide valuable information on the end-use quality of our lines at that site. Southwest Nebraska is a key sourcing site for their Colorado mills. In 2010, UNL developed a collaboration with Bayer Crop Science that allows non-exclusive access to UNL germplasm and is in accordance with the principles for collaboration approved by the National Association of Wheat Growers and with the U.S. Wheat Associates Joint Biotechnology Committee. This collaboration has led to extensive collaborations and interactions on genetics, plant breeding, and crop physiology. Having their excellent staff in Lincoln has been very advantageous to student and staff interactions. In 2012, we evaluated more than 900 doubled-haploid lines created in collaboration with Limagrain and are evaluating lines in replicated trials at numerous locations. So far one line LCS Link has been released from this cooperative effort. In addition, it opened the door for marketing a winter triticale by Limagrain and LCS Bar was licensed to them. We hope that these collaborations will continue. KWS created a doubled haploid population so we can study anther extrusion from the cross Freeman (excellent anther extruder) x Camelot (a very poor anther extruder). Our cooperation on hybrid wheat is only possible due to a collaboration with Saaten Union Recherche in France and we are truly grateful that we are able to cooperate with them. We have additional research agreements with other companies for sharing germplasm to testing lines to marketing lines nationally and internatinoally.

We continue to develop germplasm exchange agreement with private companies as their germplasm is becoming increasingly relevant. Our goal continues to be the “People’s University” and to work will all public and private wheat researchers in a manner compatible with the landgrant mission. With the current level of private sector investments in research, additional public-private interactions are to be expected and we are developing relationships with many other organizations. A key goal will be to develop working relationships that benefit the producer, the customer, and the public good.

USDA-ARS projects at the University of Nebraska are not party to these agreements.

VII. Winter Barley Research

We received our 12th year of research and development fees from an agreement with Paramount Seed Farms (a commercial seed company) for the exclusive release of our winter barley germplasm. We are fortunate that they took the initial risk of building a market for our germplasm when no one else was interested. No new barley lines were released in 2014-16, but P-845 (released in 2013) and one new lines are recommended for release as soon as the seed can be increased. Parmaount underwent a reorganization, so future barley lines will be released non-exclusively. Non-exclusive releases are preferred by the American Malting Barley Association and by the Brewers Association, both of which are funding the barley efforts on malting barley. To optimize our barley breeding efforts, we have developed a breeding collaboration with the USDA-ARS at Stillwater OK (began in the 2017-2018 season) and a testing collaboration with the USDA-ARS in OK (began in the 2017-2018 season), Kansas State University at Hays KS, and with Dr. Dipak Santra at Sidney NE. We currently our testing our advanced lines in OK, KS, and NE.

Unfortunately, in 2017, the Hays trial was lost to severe weather just before harvest (the most vulnerable time for barley if it survives the winter). However we had good winter barley trials in Nebraska and the data for 2017 are:

Name	Mead	Lincoln	Sidney	St. AVG.		Sidney	Heading	Height
	Yield	Yield	Yield	Yield	**Rank**	Test Wt.	date	
	lbs/a	lbs/a	lbs/a	lbs/a		lba/bu	Day after Jan. 1	inches
P-713	5096	4592	2945	4211	**36**	46.8	132.1	35.3
P-721	4614	4094	2937	3882	**40**	47.6	131.9	35.7
P-954	4664	4402	2912	3993	**38**	48.9	133.4	35.7
NB10444	5364	4830	3602	4599	**18**	47.7	132.6	37.1
P-845	4774	5599	3304	4559	**21**	48.2	132.3	34.4
NB11414	6054	5715	3945	5238	**5**	47.2	132.6	36.0
NB11416	5610	5853	3346	4936	**9**	48.1	132.2	36.3
NB11430	5131	5337	2904	4457	**29**	48.3	130.9	37.3
NB12419	4785	4959	3738	4494	**28**	47.7	134.2	36.5
NB12425	4226	5265	3694	4395	**34**	47.1	135.9	36.4
NB12434	6152	5731	3252	5045	**7**	48.8	131.0	36.4
NB12437	5991	5064	3341	4799	**12**	47.4	134.5	35.3
NB13401	5513	4447	3253	4404	**33**	47.9	132.2	35.7
NB13435	4915	4824	3953	4564	**20**	47.5	131.0	37.2
NB14404	6100	5588	2766	4818	**11**	48.3	131.5	35.8
NB14405	5067	4891	3803	4587	**19**	47.3	134.5	39.5
NB14412	4852	5193	3460	4502	**27**	47.1	134.7	33.9
NB14428	5492	5629	2972	4698	**16**	48	132.1	34.4
NB14429	5346	5672	2631	4550	**24**	48.4	131.6	35.2
NB14430	5546	5589	2542	4559	**21**	48.7	131.6	34.3
NB14433	5369	5950	3461	4927	**10**	47.5	131.4	35.1
NB14422	4998	6126	3893	5006	**8**	48	133.1	33.4
NB15414	4390	5634	3345	4456	**30**	48.1	131.4	34.4
NB15439	4505	4865	2294	3888	**39**	48.7	131.3	36.4
NB15420	6086	6348	3396	5277	**4**	48	131.3	35.6
NB15442	5966	5837	3603	5135	**6**	46.3	132.2	35.4
NB15440	4890	4688	3968	4515	**26**	47.2	131.9	36.2
NB15419	5800	5414	3166	4793	**14**	49.1	131.2	36.4
NB15441	6938	5485	3692	5372	**2**	47.4	131.6	36.5
NB15417	6487	6181	3488	5385	**1**	46.4	130.7	36.8
NB15443	5368	5753	3162	4761	**15**	47.9	131.6	36.9
NB15415	6489	5910	3649	5349	**3**	48.2	130.8	37.0
NB16409	4899	5625	2825	4450	**31**	46.8	130.5	37.2
NB16411	4963	5172	3837	4657	**17**	47.1	131.4	38.5
NB16412	5032	5169	3472	4558	**23**	46.1	131.5	36.9
NB16420	4585	4444	3626	4218	**35**	47.7	132.4	37.4
NB16429	5366	4555	3352	4424	**32**	48.8	133.3	36.3
NB16433	5294	5640	3462	4799	**12**	48.6	131.5	36.4
NB16434	4879	4965	2503	4116	**37**	48.6	131.0	36.3
NB16437	5325	4855	3442	4541	**25**	46.4	130.9	38.8
GRAND MEAN	**5323.08**	**5297.28**	**3323.37**			**47.74**		
LSD	**820.53**	**874.02**	**937.32**			**2.24**		
CV	**9.43**	**8.44**	**17.25**			**2.87**		

The 2016 winter barley data are:

Name	Colby	Mead	Sidney	Average	**Rank**	Anthesis	Height	Test Weight
	Yield	Yield	Yield	Yield		Date		
	lbs/a	lbs/a	lbs/a	lbs/a		D after Jan.1	in	lbs/bu
P-713	6164	3354	2585	4034	**15**	125.2	37.7	48.0
P-721	5766	2675	2354	3599	**33**	124.7	36.8	47.6
P-954	5492	3276	2398	3722	**30**	128.8	35.0	50.1
NB10417	5456	3027	2056	3513	**35**	122.7	38.3	46.5
NB10444	5741	3884	2360	3995	**19**	127.6	39.5	46.4
P-845	5976	3754	2494	4075	**13**	127.1	33.7	45.8
NB11414	5855	4168	2271	4098	**12**	126.2	36.9	49.3
NB11416	5797	4331	2798	4309	**4**	126.4	37.3	47.6
NB11430	5870	4356	2215	4147	**11**	123.8	38.0	49.1
NB12419	5888	3724	1963	3858	**22**	126.1	37.0	46.2
NB12425	6017	3917	2600	4178	**8**	129.0	36.5	46.1
NB12434	6419	4407	2053	4293	**5**	123.9	34.9	49.1
NB12437	5816	3757	2231	3935	**21**	129.1	35.0	47.4
NB13401	5675	3800	2659	4045	**14**	125.4	36.2	47.3
NB13435	6126	3093	2331	3850	**24**	126.6	38.0	49.0
NB14403	5950	2913	2705	3856	**23**	122.2	38.7	47.4
NB14404	5445	4346	2708	4166	**10**	124.4	36.7	47.3
NB14405	5650	3294	2342	3762	**28**	129.0	40.7	47.7
NB14412	6329	3785	2849	4321	**3**	126.0	33.5	44.6
NB14428	5764	4305	1925	3998	**18**	126.4	34.8	46.4
NB14429	5204	3712	2270	3729	**29**	125.2	35.6	48.4
NB14430	5513	4909	2542	4321	**2**	125.2	33.7	49.3
NB14433	5484	3833	2099	3805	**26**	125.0	35.2	45.7
TAMBAR 501	5876	3917	2164	3986	**20**	123.4	36.6	46.3
NB14422	5979	4133	2390	4167	**9**	125.3	33.2	44.5
NB15414	5573	3498	1603	3558	**34**	122.4	35.9	48.5
NB15439	5165	3766	1561	3497	**37**	126.1	37.1	48.1
NB15410	5681	2213	2027	3307	**39**	128.3	37.5	48.3
NB15420	6367	4350	2719	4479	**1**	123.2	36.4	48.2
NB15427	5043	3597	2437	3692	**31**	124.5	36.5	50.1
NB15409	5639	2391	2470	3500	**36**	128.8	38.1	48.3
NB15442	5902	3839	2306	4016	**17**	123.8	35.3	49.5

NB15412	4939	3132	1101	3057	40	123.3	37.4	49.4
NB15440	5697	3584	1641	3641	32	123.8	37.4	47.8
NB15419	5932	3251	2175	3786	27	127.8	36.9	46.1
NB15441	5947	4427	2220	4198	7	123.5	35.8	48.9
NB15417	5991	4016	2079	4029	16	124.6	36.9	49.7
NB15443	5763	3493	2211	3822	25	124.7	36.6	49.0
NB15415	6487	4098	2201	4262	6	123.8	36.2	48.5
NB15435	5283	3480	1416	3393	38	123.5	36.7	47.0
Average	**5767**	**3695**	**2238**			**125.4**	**36.5**	**47.8**

The 2015 barley data are:

2015	Entry	Name	Lincoln	Mead	Average	**Rank**
			Yield	Yield	Yield	
			lbs/a	lbs/a	lbs/a	
bvt15	1	P-713	3108	2196	2652	**5**
bvt15	2	P-721	2491	1896	2194	**20**
bvt15	3	P-954	3115	2142	2628	**7**
bvt15	4	TAMBAR 501	2105	1391	1748	**34**
bvt15	5	NB09437	2548	1332	1940	**29**
bvt15	6	NB10403	1443	1351	1397	**38**
bvt15	7	NB10417	2682	2200	2441	**13**
bvt15	8	NB10425	2514	1647	2080	**24**
bvt15	9	NB10444	3058	2068	2563	**11**
bvt15	10	NB99845	2623	863	1743	**35**
bvt15	11	NB11414	2310	1822	2066	**25**
bvt15	12	NB11416	2742	1712	2227	**19**
bvt15	13	NB11430	2830	1420	2125	**21**
bvt15	14	NB12419	2577	2373	2475	**12**
bvt15	15	NB12421	2683	1779	2231	**18**
bvt15	16	NB12424	1799	1371	1585	**36**
bvt15	17	NB12425	2642	2030	2336	**14**
bvt15	18	NB12426	1610	1920	1765	**33**
bvt15	19	NB12434	3120	2482	2801	**4**
bvt15	20	NB12437	3526	2592	3059	**1**
bvt15	21	NB13401	2791	1447	2119	**23**
bvt15	22	NB13415	2776	1256	2016	**27**
bvt15	23	NB13430	1808	722	1265	**40**
bvt15	24	NB13435	2687	1964	2326	**15**

bvt15	25	NB13436	1606	1057	1331	**39**
bvt15	26	NB14401	2009	996	1503	**37**
bvt15	27	NB14403	2392	1855	2123	**22**
bvt15	28	NB14404	3150	2093	2621	**8**
bvt15	29	NB14405	3080	2124	2602	**9**
bvt15	30	NB14409	2507	1582	2045	**26**
bvt15	31	NB14412	3097	1373	2235	**17**
bvt15	32	NB14414	2734	1112	1923	**30**
bvt15	33	NB14417	2900	1087	1993	**28**
bvt15	34	NB14418	2583	1026	1804	**32**
bvt15	35	NB14422	3076	1395	2236	**16**
bvt15	36	NB14423	2579	1052	1816	**31**
bvt15	37	NB14428	3061	2084	2573	**10**
bvt15	38	NB14429	3232	2039	2635	**6**
bvt15	39	NB14430	3174	2465	2820	**2**
bvt15	40	NB14433	3446	2162	2804	**3**

Name	Lincoln	Mead	Colby, KS	Colby, KS	Sidney,NE	Average	Rank	Colby, KS	Colby, KS	Average
	Winter	Winter	Heading	Yield	Yield	Yield		Moisture	Test Wt	Height
	Survival	Survival	Date							
	%	%	Julian	lbs/a	lbs/a	lbs/a		%	lbs/bu	in
P-713	19.3	68.0	141.9	2978	2041	2510	18	10.8	44.8	26.9
P-721	5.9	84.1	142.1	2872	1918	2395	23	10.1	45.9	26.2
P-954	10.9	83.3	142.9	3186	2488	2837	6	10.8	47.6	26.0
TAMBAR 501	3.3	71.4	140.2	2651	1322	1987	34	10.2	41.4	25.6
NB09437	11.5	74.7	142.6	2565	908	1737	37	11.4	47.9	27.6
NB09441	0.0	67.7	137.7	2500	879	1690	38	10.0	41.4	25.9
NB10403	11.7	79.2	137.8	2028	2763	2396	22	11.5	45.8	27.8
NB10409	8.1	74.3	143.0	2931	1507	2219	29	11.1	51.2	28.1
NB10417	0.0	80.7	139.1	2845	1986	2416	21	10.3	43.7	25.0
NB10420	2.7	40.1	139.9	2413	1719	2066	31	10.6	46.9	26.2
NB10425	2.8	67.3	141.8	3077	1555	2316	27	10.2	44.7	27.4
NB10440	2.7	71.3	139.7	2598	1543	2071	30	11.4	46.5	27.7
NB10444	0.0	64.7	140.2	2596	3157	2877	3	11.2	45.3	26.1
P-845	2.7	79.9	141.1	3084	2530	2807	7	10.8	46.9	24.5
NB11414	0.0	40.9	142.3	2841	2953	2897	2	10.7	46.0	26.0
NB11416	11.0	65.6	141.5	3212	2107	2660	12	10.6	43.7	27.5
NB11418	9.3	71.5	141.7	2885	2489	2687	10	10.5	46.0	24.8
NB11430	0.0	75.4	139.9	2925	2124	2525	17	10.9	47.9	28.0
NB12419	16.6	82.6	142.4	3153	1853	2503	19	11.0	45.4	27.1
NB12421	53.4	83.5	142.8	3423	2261	2842	5	12.0	44.8	25.9
NB12422	3.4	79.1	142.7	3359	1168	2264	28	10.4	47.8	26.1
NB12424	0.1	72.6	143.0	3181	1524	2353	25	11.0	47.4	25.3
NB12425	21.7	83.4	142.6	3336	2689	3013	1	10.8	45.4	25.7
NB12426	2.7	81.4	142.4	3249	1920	2585	15	11.2	47.3	28.2
NB12431	2.8	74.3	140.7	3266	2430	2848	4	11.1	46.5	24.4
NB12433	-0.1	52.7	141.2	3149	1929	2539	16	11.2	47.7	23.7
NB12434	18.3	76.1	140.2	3152	2360	2756	8	10.2	44.5	24.9
NB12436	5.9	65.1	140.7	3055	1646	2351	26	10.9	46.0	27.4
NB12437	21.6	73.6	141.7	3122	1637	2380	24	10.3	45.8	26.7
NB13401	0.0	82.7	142.1	3056	2266	2661	11	10.4	45.2	27.2
NB13415	9.4	61.0	141.3	2661	2532	2597	14	10.7	45.9	27.4
NB13430	0.1	51.3	141.1	2905	1965	2435	20	10.8	42.3	26.2
NB13434	0.0	30.5	144.2	2333	1641	1987	33	10.9	44.8	27.1
NB13435	0.0	46.3	143.0	2649	2624	2637	13	11.5	47.4	26.1
NB13436	0.0	38.1	143.0	2888	2617	2753	9	11.2	47.7	24.4
NB13437	0.1	21.6	142.1	2346	954	1650	39	11.0	43.0	24.9
NB13438	0.1	28.3	142.1	2509	1433	1971	35	10.9	44.5	23.3
NB13440	0.0	13.4	144.1	2295	572	1434	40	10.9	45.6	23.1
NB13441	0.0	45.3	138.4	2702	1048	1875	36	11.2	45.9	22.2
NB13442	0.0	33.2	143.5	2611	1519	2065	32	12.4	43.9	24.5
GRAND MEAN	**6.4**	**63.4**	**141.5**	**2865**	**1914**	**2390**		**10.9**	**45.7**	**26.0**
LSD	**6.8**	**19.2**	**2.1**	**633**	**1505**			**1.6**	**6.6**	
CV	**99.4**	**28.6**	**0.8**	**11**	**48**			**7.6**	**7.3**	

The data for 20154-2017 are presented below:

Name	Colby	Mead	Lincoln	Sidney	St. AVG.*	St. AVG.**		Sidney	Heading	Height
	Yield	Yield	Yield	Yield	Yield	Yield	Rank	Test Wt.	date	
	lbs/a	lbs/a	lbs/a	lbs/a	lbs/a	lbs/a		lba/bu	y after Jar	inches
NB10444	5741	3772	3944	3602	4265	4078.13	10	132.60	27.83	47.70
NB11414	5855	4015	4013	3945	4457	4266.99	3	132.59	27.03	47.20
NB11416	5797	3884	4298	3346	4331	4198.74	7	132.16	27.25	48.10
NB11430	5870	3636	4084	2904	4123	3978.40	14	130.91	28.00	48.30
NB12419	5888	3627	3768	3738	4255	4006.26	12	134.23	27.38	47.70
NB12425	6017	3391	3954	3694	4264	3970.17	16	135.93	27.33	47.10
NB12434	6419	4347	4426	3252	4611	4509.00	1	131.03	27.28	48.80
NB12437	5816	4113	4295	3341	4391	4298.09	2	134.50	26.48	47.40
NB13401	5675	3586	3619	3253	4033	3846.49	18	132.23	26.75	47.90
NB13435	6126	3324	3756	3953	4290	3937.44	17	131.01	27.88	47.50
NB14404	5445	4179	4369	2766	4190	4212.40	6	131.46	26.85	48.30
NB14405	5650	3495	3986	3803	4233	3986.93	13	134.46	29.65	47.30
NB14412	6329	3337	4145	3460	4318	4012.75	11	134.75	25.43	47.10
NB14422	5979	3509	4601	3893	4495	4228.61	5	133.15	25.05	48.00
NB14428	5764	3960	4345	2972	4260	4186.71	8	132.08	25.80	48.00
NB14429	5204	3699	4452	2631	3996	3976.52	15	131.65	26.40	48.40
NB14430	5513	4306	4382	2542	4186	4248.24	4	131.61	25.75	48.70
NB99845	5976	3563	4523	3304	4341	4144.95	9	132.32	25.83	48.20
P-713	6164	3104	3608	2945	3955	3662.41	19	132.12	26.45	46.80
P-721	5766	3162	3601	2937	3866	3627.21	20	131.93	26.80	47.60
P-954	5492	3279	3447	2912	3782	3590.40	21	133.36	26.78	48.90

St. AVG.**
Yield
lbs/a

These data are interesting because the averages are developed in two ways. The first average (*) is over locations (N=4) and the second is averaged (**) over each trial (N=7). In general, there is good agreement.

VIII. ALLIED RESEARCH

The wheat breeding or variety development project is only one phase of wheat improvement research at the University of Nebraska-Lincoln. The project interacts and depends on research in wheat germplasm development, wheat quality, wheat nutritional improvement, wheat cytogenetics, plant physiology and production practices, and variety testing. Much of the production research is located at the research and extension centers. All components are important in maintaining a competitive and improving wheat industry in Nebraska. The allied research is particularly necessary as grain classification and quality standards change and as growers try to reduce their production costs.

The program also depends on interactions and collaborations with the Wheat Board, Nebraska Wheat Growers Association, regional advisory boards, Foundation Seeds Division, Nebraska Crop Improvement Association, Texas A&M University, CIMMYT, the milling and baking industry, the malting and brewing industry, and other interested groups and individuals. The Nebraska Seed Quality Laboratory cooperates closely with the Wheat Quality Council to bake the large-scale cooperator samples. Ardent Mills also provides excellent milling and large-loaf baking data to support our small-loaf testing procedures. Numerous groups have visited the laboratory and participated in discussions on quality and marketing. Through these interactions, the program is able to remain focused and dedicated to being a premier provider of quality varieties, information, and technologies to help maintain the Nebraska Wheat Industry. We also wish to highlight the generosity of Mr. Martin Stumpf who recently donated one section of rainfed and irrigated land for an International Wheat Research Center in Grant, NE, and the funds for a new building on the site. Grant is one of the finest wheat producing regions in Nebraska and this location will be a huge benefit to the Nebraska wheat producers. We hope our program will live up the high expectations of the donor.

IX. COMINGS AND GOINGS

All projects are more than crosses, selections, evaluations, data, and seed. At its heart, it is the people who make this research possible. Ms. Hannah Donoho and Betul Cetindere joined the project as M.S. students. Ms. Fang Wang joined the project as a Ph.D. student. Mr. Nick Garst completed his M.S. degree and began his Ph.D. degree program. Drs. Amanda Easterly, Jorge Venegas, Rungravee Boontung, and Waseem Hussain successfully completed their Ph.D. programs. Ms. Khatiba Bibi, Ms. Amira Mourad, Dr. Hui Dong, Dr. Zlatko Svecnjak, Dr. Ahmed Sallam, and Dr. Mohamed Saadlala completed their visiting scientist appointments.   We are extremely grateful for the excellent work that the team has done and continues to do.

Summary:

In 2016-2017 season, 1,120,000 acres of wheat were planted in Nebraska and 1,020,000 were harvested with an average yield of 46 bu/a for a total production of 46,920,000 bu. The crop generally got off got a good start and survived the winter, but in the spring a number of diseases and wheat stem sawfly were abundant. In western and central Nebraska, wheat streak mosaic virus was quite common. Wheat stem sawfly also continued to expand into Nebraska from the west, though fortunately parasites lessened some of the damage. In eastern Nebraska, the rusts (led by stripe rust and then leaf rust were very common). In 2015-2016 season, Nebraskans planted 1,370,000 acres of wheat and harvested 1,310,000 acres with an average yield of 54 bushels/acre for a total production of 70,740,000 bu. The 54 bu/a yield was a record yield. In 2014-2015 season, Nebraskans planted 1,490,000 acres of wheat and harvested 1,210,000 acres with an average yield of 38 bushels/acre for a total production of 45,980,000 bu. Nebraska began retaking the variety surveys in 2015, however due to financial constraints did not do one in 2017. From seed sales, Ruth had an excellent year and should be adopted well in western NE. Robidoux, Freeman, and many of the commercially developed lines continue to be popular. The one line that has dropped in sales (and expected acreage) is Settler CL. Newer genetics and newer 2-gene lines have taken much of previous Settler CL acreage. At the last survey, the variety distribution is remarkable in that no variety has over 10% of the acreage. In 2016, SY Wolf (7.4%), Winter Hawk (7.0%) Settler CL (6.9%) were the most widely grown varieties in Nebraska followed by Brawl CL Plus (5.0%), Overland (4.9%), Byrd (4.5%) TAM 111 (4.3%), and Buckskin (4.2%). An additional, 11 varieties were grown on less than 4% of the acreage. 2.4% were blends and 26% of our acreage where grown in varieties having individually less than 1% of the acreage. We expect this level of diversity in our cultivars has continued in 2017. Of the reported varieties, we estimate about 60% of Nebraska wheat acreage grew varieties developed by the collaborative USDA-ARS, University of Nebraska small grains breeding effort.

The project formally released one new wheat line in collaboration with Limagrain (LCS Link and expects to license a line to a LCS third party) and developed our first approved 2-gene Clearfield line (NHH144913-3, expected release in 2018) and released 7 new triticale lines (NT055421, NT07403, NT09423, NT11406, NT11428, NT12414, and NT12434). NT12434 was licensed to Limagrain and will be marketed as LCS Bar. NT12414 is also under consideration for licensing. PVP certificates have been submitted for NT07403, NT09423, NT11406, NT11428, and NT12434. These five lines are currently grown from the New York to New Mexico. NHH144913-3 seems to be well adapted to Nebraska and regions north of Nebraska. In the 2017 Northern Regional Performance Nursery with the data reported so far, it ranked third in the region. Our wheat and barley lines will have regional markets, but it seems our triticale lines (possibly due to the limited number of breeding programs) will have a national market.

Our efforts on developing a public, transparent hybrid wheat platform continue in collaboration with Texas A & M University, CIMMYT, Kansas State University, Saaten-Union Recherche in France; the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany; and the University of Hohenheim in Germany. Hybrid wheat is one of the most promising ways of bringing the increased productivity and technology to wheat needed to feed an ever increasing and wealthier world.

As part of the people's university, we continue to breed wheat suitable for all of our constituencies. Our efforts in healthier grains have increased by the work on developing breeding protocols and lines with low Cd adapted to Nebraska. Breeding lines for improved biotic (disease and insect) and abiotic (winter survival, heat, and drought), better nitrogen use efficiency, and herbicide tolerance remain major efforts.

Our program gratefully acknowledges the generous support of the Nebraska Wheat Board.