IMPROVING SMALL GRAINS VARIETIES FOR NEBRASKA

2019 STATE BREEDING AND QUALITY EVALUATION REPORT

Report to the

NEBRASKA WHEAT DEVELOPMENT, UTILIZATION
AND MARKETING BOARD

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I. INTRODUCTION

Development research on Nebraska's small grains (winter wheat, barley, and triticale) 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 hybrid, variety, line, and germplasm development, is a major component of the state's small grains improvement research. This report deals only with the state portion of the total small grains 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 2018-2019 NEBRASKA WHEAT CROP

1. Growing Conditions

The 2018-2019 growing season would be considered 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 in western Nebraska, but rain delayed in eastern Nebraska. For parts of the state, there was above average moisture over winter followed by catastrophic floods along many of the eastern and central rivers. Above average moisture continued during most of the spring which benefited western Nebraska and brought disease to eastern Nebraska. The fields that were planted on time for their respective eco-geographic zones tended to be fertilized before planting, though the expected prices for the crop led to less inputs (fertilizer, pesticides) being used than when wheat is worth more. In general, diseases and insects were moderate throughout Nebraska. Fungicides were frequently used as a preventative measure against fungal diseases. Rain at harvest reduced grain yield and quality.

2. Diseases

In 2019, in eastern Nebraska, wet weather diseases such as leaf rust and Fusarium head blight were found. Stripe rust was minor. Fortunately, growers are very familiar with fungicides and chose to protect their crop. In fungicide treated (81.1 bu/a) and untreated (66.4 bu/a) trials at Lincoln 2019, the yield loss due to foliar fungal disease was 18% (14.7 bu/a). This level of disease loss is similar to previous years and much higher than in 2018 (7% or 5.1 bu/a yield loss due to drought during flowering and early grainfill). The fungicide treated plots were sprayed twice due to high levels of potential disease. In 2018, cephalosporium stripe, caused by a soilborne pathogen *Cephalosporium gramineum*, was again found at North Platte. Wheat streak mosaic virus was generally minor in western Nebraska. The yield losses due to controllable fungal diseases in eastern Nebraska in 2015, 2016, and 2017 were 44%, 32% and 16%, respectively. 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 (mainly ergot and some bacterial streak).

3. Insects

Nebraska continues to have small outbreaks of Hessian fly and the diseases vectored by aphids (barley yellow dwarf virus). In 2019, wheat streak mosaic virus (WSMV) and other viruses vectored by mites or aphids were generally minor. The wheat stem sawfly continued to be pervasive throughout the Nebraska Panhandle and led to crop losses wherever there was severe weather before harvest due to extensive lodging and stem breakage.

4. Small Grains Production

In 2018-2019 season, 1,070,000 acres of wheat were planted in Nebraska (a record low) and 970,000 acres were harvested with an average yield of 57 bu/a (a record high) for a total production of 55,300,000 bu. In 2017-2018 season, 1,100,000 acres of wheat were planted in Nebraska and 1,010,000 were harvested with an average yield of 49 bu/a for a total production of 49,490,000 bu. The crop generally got off to a good start and survived the winter, but in the spring periodic episodes of drought and extreme heat (100 F at flowering) affected part of the crops. Leaf rust was the main disease and wheat stem sawfly was the major insect pest. 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 to 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. Despite continued genetic improvement, the main determinants in wheat production seem 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 or thereafter. Using aggregate data from the Nebraska Crop Improvement Association, approximately 43% of the wheat planted acres were planted to certified seed of 46 different cultivars in 2019. Approximately 67% of the wheat planted acres were planted to certified seed of 46 different cultivars in 2018. The reduction in certified seed usage may reflect the low value of wheat and growers trying to reduce input costs. The certified seed planted acreage will vary by cropping system and region with more saved seed in regions where less seed of other crops are purchased. Approximately 44% of the certified seed was developed by companies, 44 % by the USDA-University of Nebraska and 12% from other public breeding programs. From seed sales, Ruth (ranked 3rd in certified seed sales) had an excellent year and is well adapted across NE. Settler CL, Robidoux, Freeman, and many of the commercially developed lines continue to be popular. 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. Cultivar 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 NE12561 which will be marketed through NuPride Genetics Network and named Siege (https://agronomy.unl.edu/Baenziger/annualreports/SiegeUNLSignedUSDA.pdf) and a second line in collaboration with Limagrain (LCS Valiant, https://agronomy.unl.edu/Baenziger/annualreports/ValiantUNLsignedUSDA.pdf and https://limagraincerealseeds.com/central-plains/hard-red-winter-wheat-seed/lcs-valiant/). The full details on these lines can be found at the web links. LCS Valiant was sold in Fall 2019 to growers and the first certified seed for NuPride Genetics Siege will be available to growers in Fall 2020. Our first approved 2-gene Clearfield line (NHH144913-3 was discovered to have soft kernels and will need to be an identity preserved wheat if it is marketed). It is currently being tested in traditional soft wheat states and may fit into eastern KS where soft wheat cultivars are currently grown. Two new hard red winter wheat lines, NHH17450 and NHH17612, both with hard texture and hard wheat quality were approved by BASF for release as Clearfield Plus cultivars. We are increasing seed of these lines for further testing and increase with the hopes they may be released.

Our next white wheat has been developed, but a key need is identifying a buyer for it. NW13493 (derived from the cross SD98W175-1/NW03666) is currently being grown under small scale production with a miller to determine if they want to license the line. In 2019, NW13493 was tested in parts of the Kansas and in Nebraska State Variety Trials. It has done well across Nebraska in areas to our west based upon data from the USDA regional performance nurseries (SRPN16 and 17). NW13493 (derived from the cross SD98W175-1/NW03666) is a potential new hard white winter wheat. The pedigree of SD98W175-1 is KS84273BB-10/KSSB110-9//KS831374-141B/YE1110/3/KS82W418/SPN and the pedigree of NW03666 is N94S097KS/NE93459. White wheat varieties always have to find a market before they can be released because without a known buyer there is a concern on marketability which puts growers at risk. However, there is little doubt that if NW13493 were a hard red winter wheat, it would be released. It is a very high yielding, early, semi-dwarf with good winterhardiness and disease resistance (leaf [possibly containing Lr34, Lr68, and Lr16], stem [possibly containing Sr38], and stripe rust [possibly containing Yr17]; wheat soilborne mosaic virus). However, it is susceptible to wheat streak mosaic virus, wheat stem sawfly, and Hessian fly. NW13493 is superior to very susceptible FHB lines such as Overley, but inferior to moderately resistant FHB lines such as Overland. In 2019, its average FHB rating in state variety trials was 5.7 on a scale of 1 to 9 where 1 = resistant and 9 = susceptible, and severity in the greenhouse was 64%, indicating it is moderately susceptible. While it has good test weight, it tends to be slightly below average for grain protein content. It seems to be above average for sprouting tolerance among white wheat genotypes. It has very good end-use quality. In 2019, NW13493 was tested in parts of the Kansas and in Nebraska State Variety Trials.

In 2019, we began the increase of NT14433, a new tall triticale for the forage market. NT14433 was derived from the cross: Haiduc/NE426GT//NT06427 and is a very tall triticale similar to NT441 but with better grain yield and forage yield than NT441, a very popular forage triticale. NT14433 was derived from the cross Haiduc/NE426GT//NT06427 where Haiduc was a tritcale parent line from Rumania, NE426GT was an early released grain triticale, and NT06427 was a released awnletted triticale. NT14433 is a very tall (similar to NT441), medium maturity (~4 days earlier than NT441), exceptionally high yielding forage triticale (slightly better than NT441)with a lower grain yield when compared to our grain triticales, but superior to NT441(~19% higher yielding than NT441) as is often the case with forage triticales. Its standability is good for a tall triticale. It is resistant to most common diseases and insects of wheat as are most triticale lines with the exception of bacterial streak and ergot. In 2018, one new forage triticale, NT13443 was released. NT13443 was derived from the cross 04TG 112/NE422T=(TRICAL /UB-UW26)//NE03T407 and is a winter forage triticale that grows well in the Central Great Plains under rainfed conditions. It has excellent winterhardiness and good bacterial streak resistance (a major disease of triticale and one that cannot be treated with fungicides). It is early (6 days earlier than NT441 and similar to NT426GT) and tall, similar in height and slightly better in forage production to NT441. Like most tall triticales, if intensively managed, lodging may be a concern. It has a relatively unique grain characteristic of being low in polyphenol oxidase (an enzyme that discolors wet dough products if they are allowed to rest, similar to an apple browning when bitten). We are exploring food uses for this trait. In 2017 we announced the release of 7 new triticale lines (NT055421, NT07403, NT09423, NT11406, NT11428, NT12414, and NT12434). NT12434 was licensed to Limagrain and will be marketed as LCS Bar. These five lines are currently grown from New York to New Mexico.

		Grain Yield (lbs/a)	Grain Yield (lbs/a)	Grain Yield (lbs/a)	**State Avg Yield lbs/a**	**State Avg. Hdate (d after**	**State Avg. Height (in)**	Forage yldlbsa lbs/a	Forage dmpercent %
2017-2019	NT07403	3682	3976	3798	3882	140.0	44.6	2975	0.29
2017-2019	NT09423	3178	3109	4126	3499	144.4	46.8	2622	0.24
2017-2019	NT14433	3065	3515	3296	3403	143.6	56.6	3311	0.27
2017-2019	NT15406	3898	4616	4024	4226	140.5	46.4	2947	0.3
2017-2019	NT15428	3725	3931	3994	3905	142.0	46.8	2842	0.27
2017-2019	NT16402	4046	4557	4026	4204	140.4	45.6	3022	0.28
2017-2019	NT441	3104	2223	3408	2892	147.7	56.6	2871	0.22
2017-2019	OVERLAN	3131	2864	3442	3179	144.9	38.7	2525	0.25

The wheat and 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.
Development team: P. S. Baenziger (breeder-inventor, University of Nebraska), K. Vogel (USDA-ARS), R. Mitchell (USDA-ARS), S. Wegulo (University of Nebraska), T. Regassa (University of Nebraska), D. Santra (University of Nebraska), and M. Barnett (Limagrain Cereal Seeds).

In 2019 we began the increase of NB15420. NB15420 was selected from the cross P-845/NB08410. The line is awned with very good grain yield and test weight in Nebraska. It is medium late for a winter barley which normally flowers before winter wheat. Its later flowering means that it tends to perform less well than P-919 when moved south, but it is a much more reliable winter barley cultivar for growing in Nebraska. Seed treatments are recommended as loose smut is very common in barley grown from untreated seed.

Name	COLBY Yield Lbs/a	Mead Yield Lbs/a	Lincoln Yield Lbs/a	Sidney Yield Lbs/a	AVG Yield Lbs/a	Rank	Anthesis date Julian	Height in	Test Weight lbs/bu
NB15420	2095	4813.8	4618.0	3777.5	4134.4	2	133.5	27.8	45.9
P-845	1862	3487.0	4364.7	3471.5	3634.7	16	132.8	27.6	44.0
P-954	2136	3480.7	3788.7	3738.5	3576.8	18	135.7	28.3	46.2

Development team: P. S. Baenziger (breeder-inventor, University of Nebraska), Fang Wang, S. Wegulo (University of Nebraska), Amanda Easterly (University of Nebraska), T. Regassa (University of Nebraska), D. Santra (University of Nebraska), and G. Zhang (Kansas State University)

Ruth continued to do well. Below is the data from the State Variety Trial for 2017-2019 (derived from data from A. Easterly and C. Creech).

		State Grain Yield bu/a	SE Grain Yield bu/a	SC Grain Yield bu/a	WC Grain Yield bu/a	West Grain Yield bu/a	Test Weight lbs/bu	Plant Height in	Grain Protein %
2017-19	LCS VALIANT	77.4	96.7	71.5	80.4	60.8	56.7	33.0	13.4
2017-19	NW13493	75.9	96.0	71.0	75.8	60.9	56.9	34.8	13.4
2017-19	SIEGE	74.1	95.8	64.9	76.7	59.0	58.0	34.1	13.3
2017-19	FREEMAN	73.9	89.0	65.5	76.0	65.0	54.8	33.8	12.9
2017-19	RUTH	76.1	90.4	68.2	78.7	67.0	56.1	35.7	13.0
2017-19	OVERLAND	74.7	88.6	73.4	73.5	63.3	56.2	36.8	13.1
2017-19	SCOUT 66	54.3	65.3	44.7	56.3	50.7	56.4	39.5	13.8
2017-19	TURKEY	54.6	63.2	51.4	55.7	48.0	56.2	40.7	14.0

IV. FIELD RESEARCH

1. <u>Increase of New Experimental Lines</u>

With the release of new varieties Husker Genetics Brand Ruth, NuPride Genetics Siege, LCS Valiant, Freeman, Goodstreak, Panhandle, Robidoux, and Settler CL over the past several years, most advanced current breeding lines are not expected to be released. However, a number of lines are targeted for advancement or possible release in 2020 or shortly thereafter.

Specifically, the following lines are under increase:

Species	Line	Pedigree	Comment
Barley	NB15420	P-845/NB08410	Excellent Grain Yield
	NB15415	P-845/NB08410	Excellent Grain Yield
	NB15441	P-845/NB08410	Excellent Grain Yield
Triticale	NT12403	NT05429=(NE98T425 (=PRESTO/N	Excellent grain yield
	NT12404-1	NT04432=(NE92T422(=COMPLEX)/	Excellent grain with fair forage yield
	NT14407	NCPT01-1433/NT05433//NT07403	Good gain yield in western Nebraska
	NT14433	Haiduc/NE426GT//NT06427	Excellent forage yield
	NT15406	Gorum/NE422T//NT08421	Excellent grain yield
	NT16402	NT09418/NT07403	Excellent grain with fair forage yield
Wheat	NE14434	SD98W175-1/NW03666//Freeman	High yielding semidwarf line
	NE14691	SD05W138/NE01604	High yielding semidwarf line
	NE14696	NE05537/Overland	Tall semidwarf with excellent disease resistance
	NE15420	HV9W02-942R/NW03666	Good irrigated line
	NE15624	NE05537/KS05HW15-2	High yileding semidwarf line
	NE16562	HV9W02-942R/CAMELOT	High yielding semidwarf line
	NHH17450	Brawl_CL/NHH09655	BASF approved CL plus semidwarf line
	NHH17612	Brawl_CL/NHH09655	BASF approved CL plus semidwarf line
	NW13493	SD98W175-1/NW03666	Excellent grain yield and quality. White wheat
	NW15443	OR 2060108/NW03681//NW03666	Good white wheat

Disease and Insect Resistance Characteristics of current and future lines:

	Sr	LR	YR	HF	SBMV	D. Bunt	Acid Soil
Freeman	MR	MS	MR	SEG	R		
LCS Valiant	MR	MR	S	MR	R		
NE14434	MR	MS	MR/MS	S	R	S	
NE14691	R	MS	MR	R	R	S	
NE14696	MR	MR/MS	MR	S	R		
NE15420	R	MS?	MR	S	R		
NE15624	MS	MS	MR/MS	S	R	S	
NE16562	TMR	MR	MS	R	R	MS	S
NHH17450	MR	R	MR	S	R		TOL.
NHH17612	MR	MR	MS	S	SEG R.		TOL.
NW13493	R/MR	MR	MR/MS	S	MR	S	
NW15443	MR/MS	S	MR/MS	R	MR	S	
Overand	MR	R	S	S	R?	S	
Panhandle	MR	MS	S	S	MR		

Robidoux	MR	MS/S	MR	S	R		
Siege	MR	MS	MR	MR	R	S	MS
Wesley	R	S	MS/S	S	R		

R = resistant, MR = moderately resistant, MS = moderately susceptible, and S = susceptible. These lines are generally susceptible to wheat streak mosaic virus and to the wheat stem sawfly.

2. **Nebraska Variety Testing** (data courtesy of A. Easterly and C. Creech)

Numerous entries were included in some or all of the locations in the Fall Sown Small Grain Variety Tests in 2019. The overall data are listed below. Lines such as LCS Valiant which did well are broadly adapted across Nebraska. Other lines are adapted to specific parts of the state, but not necessarily the whole state.

Name	Source/Brand	Yield (bu/a)		Protein (%)		Test Weight (lb/bu)		Plant Height at Maturity (in)		1000k weight (g)	
		Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
NHH144913-3	UNL-Experimental	84.8	20.8	12.5	11.0	54.8	2.0	34.5	2.5	38.4	3.7
LCS Valiant (NE10478-1)	UNL-Experimental	83.1	24.9	12.9	0.9	58.3	2.9	34.2	4.4	42.5	3.2
NE14434	UNL-Experimental	82.5	23.2	11.7	0.8	57.1	2.0	37.2	3.1	40.9	3.0
WB-Grainfield	WestBred	82.3	24.0	11.8	0.9	56.9	2.7	34.9	3.0	39.5	2.7
Overland	Husker Genetics	81.2	19.6	12.4	0.8	57.8	2.0	37.8	3.0	41.3	1.9
Freeman	Husker Genetics	80.8	21.4	12.0	0.0	56.1	2.5	34.1	4.0	39.2	3.7
NE12561 (Siege)	UNL-Experimental	79.4	22.7	13.1	9.0	59.5	2.3	35.1	2.5	41.8	2.2
Long Branch	Dyna-Gro	79.2	23.5	12.6	0.9	56.3	2.9	34.2	2.8	41.0	3.8
Ruth	Husker Genetics	79.1	22.2	12.2	0.9	57.2	2.8	36.1	2.6	38.8	3.1
NW13493	UNL-Experimental	78.9	22.3	12.6	1.1	58.6	2.1	35.2	2.5	41.7	2.9
WB4418	WestBred	78.0	18.5	12.8	1.1	57.1	2.0	32.3	2.2	37.2	2.2
AM Eastwood	AgriMAXX	72.5	18.1	12.5	0.7	56.3	2.8	31.2	2.0	38.4	2.9
Turkey	Check	61.1	14.8	13.8	0.8	57.9	2.1	42.3	5.4	41.4	2.2
Scout 66	Check	59.7	15.5	13.4	1.0	58.0	2.3	41.0	5.2	44.5	2.2

Numerous entries were included in some or all of the locations in the Fall Sown Small Grain Variety Tests in 2018. Nine dryland locations in Nebraska were harvested for yield data and the data for the top ten lines grown across the state are presented below.

Name	Average
LCS Valiant	78.3
SY Monument	77.2
WB-Grainfield	76.9
NW13493	76.7
LCS Link	76.3
NHH144913-3	75.3
NI13706	75.0
LCS Chrome	74.8
Long Branch	74.3
SY Wolf	74.0
Ruth	73.8
WB4418	73.5
NE12561	73.1

AM Eastwood	72.7
NE13515	72.4
Freeman	70.9
Turkey	60.4
Scout 66	58.2

In 2017, 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	Yield	Dryland	Yield
Entry	bu/a	Entry	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

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

In 2019, one irrigated trial was harvested (Box Butte County). The Chase County trial was lost. The data for 2019 can be found at: https://cropwatch.unl.edu/Variety-Testing/Wheat-2019/Wheat-Box-Butte-Cnty-Irrigated-.pdf and is presented below. The data are courtesy of A. Easterly and C. Creech.

		Yield	Protein	Test Weight	Height	Kernel weight
Name	**Source/Brand**	bu/a	%	lb/bu	in	g
UNL-Experimental	NE15420	119.6	13.3	55.7	32	40.6
WestBred	WB4699	113.6	12.6	53.9	28	35.9
WestBred	WB4418	111.4	13.8	54.4	33	36.8
AgriMAXX	AM Eastwood	111.2	13.7	55.0	32	40.1
UNL-Experimental	NHH144913-3	109.0	13.3	53.2	34	39.0
WestBred	WB4303	108.8	13.9	52.2	32	40.1
CROPLAN	CPCPX79-10	108.5	13.1	56.7	33	39.0
Limagrain Cereal Seeds	LCH14-52	106.7	13.6	56.3	32	46.0
WestBred	WB4595 (XB4520)	106.7	12.7	56.2	33	40.9
WestBred	WB-Grainfield	105.8	13.4	54.9	30	39.0
AgriPro	SY Wolf	104.2	13.7	56.4	35	42.0
WestBred	WB4269	104.1	12.4	53.5	30	38.9
PlainsGold	Monarch	100.8	12.7	54.6	33	38.6
AgriPro	SY Wolverine (Exp 40-1)	99.8	13.6	55.8	30	42.2
AgriPro	SY Sunrise	99.5	12.9	55.4	31	41.7
Limagrain Cereal Seeds	LCS Avenger	99.4	13.4	54.9	29	43.7
Husker Genetics	Wesley	98.4	14.4	54.1	31	43.2
WestBred	WB4792	98.4	13.1	55.2	33	40.4
CROPLAN	CP7909	97.1	12.4	56.6	27	42.5
Dyna-Gro	Long Branch	96.7	13.1	55.1	32	41.6
Limagrain Cereal Seeds	LCS Valiant	96.1	13.8	56.1	26	41.9
Wyoming	Cowboy	95.7	12.8	54.7	38	40.3
UNL-Experimental	NE12561 (Siege)	93.8	14.1	55.2	32	37.8
PlainsGold	Canvas	90.7	13.1	54.7	33	37.6
CROPLAN	CP7869	86.2	13.7	54.9	28	43.1
UNL-Experimental	NE14434	86.0	13.5	54.4	23	42.0
Husker Genetics	Robidoux	80.8	14.0	51.9	26	37.9
	SE	3.5	0.1	0.3	NA	0.8
	LSD	8.2	0.3	0.7	NA	2.3
	Mean	101.1	13.3	54.9	31.0	40.5
	CV	11.2	4.5	2.4	NA	6.4
	REPS	5	3	5	1	3

In 2018, one irrigated trial was harvested (Box Butte County). The Chase County trial was damaged by storms.

Box Butte County Irrigated Winter Wheat Variety Test - 2018				
Brand	**Variety**	**Grain Yield (bu/a)**	**Moisture (%)**	**Bushel Weight (lb/bu)**
CROPLAN by Winfield United	CROPLAN EXP 69-16	102	13	56
Husker Genetics	Robidoux	101	13	55
AgriPro Syngenta	SY Wolf	100	13	55
WestBred	WB4418	100	13	55
AgriMAXX	AM Eastwood	99	14	56
-----	NHH144913-3	99	13	55
WestBred	WB4303	97	13	53
-----	NE12561	97	13	56
WestBred	WB4458	96	13	54
-----	NE15420	96	13	54
Limagrain Cereal Seeds	LCH14-77	95	14	56
WestBred	WB-Grainfield	95	13	54
Limagrain Cereal Seeds	LCS Chrome	94	11	56
WestBred	WB-Cedar	94	13	55
PlainsGold	Langin	92	11	56
Dyna-Gro Seeds	Long Branch	91	12	55
WestBred	Winterhawk	90	13	55
CRFW	Cowboy	89	13	55
AgriPro Syngenta	SY Sunrise	88	13	56
Limagrain Cereal Seeds	Avenger (LCH14-55)	87	12	56
Limagrain Cereal Seeds	LCS Link	85	13	55
-----	NI13706	85	14	56
----	Wesley	81	12	53
Average of all entries		**94**	**13**	**55**
Difference required for significance at 5%		**8**	**NS**	**NS**

Many high yielding lines were identified and confirmed (e.g. Robidoux and SY Wolf).

In 2017, one irrigated yield trial was harvested (Chase county). Box Butte county trial was lost.

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**

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. Robidoux).

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 selected 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.

The data for 2019 are:

	Lincoln	N.Platte	Alliance	St. Avg.	Rank	Flowering	Test Wt	Height
	Yield	Yield	Yield	Yield		Date		
	bu/a	bu/a	bu/a	bu/a		D after	lbs/bu	in.
Name	yb_ln19	yb_np19	yb_al19	St. Avg.	St.Rank	jan. 1	TWT AVG	HT In Avg.
NI17411	82.9	48.7	69.3	66.97	32	145.3	59.2	31.75
NE17662	100.3	51.7	67.0	73.00	14	148.0	58.2	37.00
NE17467	78.0	50.8	67.4	65.40	34	144.0	59.0	34.45
NE17607	73.0	65.8	81.9	73.57	10	148.0	57.1	33.40
NE15420	79.5	45.4	74.8	66.57	33	143.3	57.6	33.80
NE17534	82.1	63.3	75.5	73.63	9	146.7	59.2	32.15
NE17625	84.6	51.3	75.0	70.30	23	148.0	58.3	31.35
LCS Valiant	76.5	55.5	82.7	71.57	20	144.0	58.0	30.75
NE17620	85.5	56.9	79.5	73.97	8	148.7	60.7	33.90
NE17442	75.9	51.5	66.0	64.47	35	142.7	58.4	30.10
NE17626	83.1	50.3	71.7	68.37	27	148.0	58.6	31.80
WB CEDAR	67.0	45.9	77.5	63.47	36	140.7	58.0	27.90
NHH17559	76.0	49.6	79.3	68.30	28	145.3	59.2	32.60
NE17589	89.5	57.1	81.6	76.07	4	145.3	58.1	32.30
NE16401	69.3	45.0	73.9	62.73	38	143.3	58.0	26.45
NE17462	80.1	54.2	75.5	69.93	25	144.0	58.5	35.40
NE17561	86.5	57.0	76.5	73.33	11	148.0	59.9	35.15
NI17414	64.8	49.6	73.5	62.63	39	144.0	58.2	34.45
NE17544	86.7	60.9	86.1	77.90	2	148.0	59.0	37.80
NE17572	74.9	40.1	71.9	62.30	40	148.0	57.2	29.35
NHH17447	81.6	52.3	77.1	70.33	22	144.0	59.6	33.30
NE17631	85.6	50.6	64.9	67.03	31	146.0	56.4	31.65
NE17629	85.8	54.7	76.5	72.33	18	146.7	58.6	36.00
NE17546	81.7	49.3	79.4	70.13	24	144.0	57.8	32.50
NI13706	88.0	59.8	83.7	77.17	3	140.7	59.1	32.80
NW13493	90.1	50.9	78.1	73.03	13	145.3	58.4	34.05
NE12561	86.4	51.4	81.1	72.97	16	143.3	59.5	33.80
NE16402	84.1	57.2	82.9	74.73	7	148.0	58.3	34.90
NE16562	89.2	52.7	82.4	74.77	6	142.7	56.2	31.45
NE16687	73.1	60.4	70.3	67.93	30	148.0	61.0	35.60
NH144913-3	71.5	56.9	77.4	68.60	26	144.0	55.2	32.25
PSB13NEDH-14-83W	84.4	60.6	81.8	75.60	5	148.0	58.2	33.45
NE16593	84.8	57.1	77.1	73.00	14	145.3	58.6	30.80
NE15624	70.6	57.5	76.2	68.10	29	144.0	58.6	32.40
Robidoux	89.2	58.4	67.9	71.83	19	146.7	57.4	33.70
NE16424	77.5	54.0	86.2	72.57	17	144.0	59.1	30.35
NE13604	69.3	47.3	72.1	62.90	37	144.0	58.1	29.35
NE16468	83.5	65.8	87.7	79.00	1	143.3	58.6	33.05
NW13570	87.9	51.8	71.7	70.47	21	148.0	57.1	32.30
NE17483	95.2	43.2	81.0	73.13	12	143.3	59.7	32.60
CV	9.13	11.66	6.82	9.20		0.89	1.6	7.54
GRAND MEAN	81.39	53.56	76.55	70.50		145.32	58.355	32.705
Heritability	0.43	0.36	0.48	0.42		0.72	0.595	0.365
LSD	14.41	12.21	8.54	11.72		2.11	1.88	0.98

The data for 2018 are:

Name	Lincoln	N.Platte	Alliance	St. Avg.	Rank	Flowering	Height	Test Wt.
	Yield	Yield	Yield	Yield		Date		
	bu/a	bu/a	bu/a	bu/a			in	
newname	yb_ln18	yb_np18	yb_al18			hdjd_ln18		twt_al18
NE17572	75.4	52.7	67.4	65.17	14	144.9	31.7	56.7
NE17625	61.8	56.5	67.9	62.07	27	145.0	33.4	57.3
NE17631	77.2	54.6	64.9	65.57	13	144.7	34.4	56.3
NE17499	66.8	48.3	60.2	58.43	36	144.7	33.6	56.3
NE17546	58.7	50.3	75.4	61.47	29	144.0	33.7	56.7
NE17565	75.2	58.4	64.2	65.93	10	144.7	34.6	55.7
NE17462	69	51.8	68.6	63.13	23	143.7	34.9	57.3
NE17620	81.8	64.5	69.8	72.03	1	144.6	33.6	60.1
NE17597	44.1	59	64.2	55.77	38	144.7	39.3	58.8
NE17662	75.2	51.1	71.5	65.93	10	145.0	34.8	57.8
NE17442	79.4	61.1	63.8	68.10	6	144.0	31.4	57.3
NE17469	61.1	62.6	67.2	63.63	20	144.0	36.9	57.7
NHH17559	66.2	61.2	66.1	64.50	16	144.7	34.2	56.8
NE17467	73.4	52	66.9	64.10	18	144.7	32.1	56.5
NE17607	73.5	62.2	67.7	67.80	7	145.6	33.0	56.0
NE17626	78.9	56.4	71.7	69.00	3	145.0	32.6	57.2
NE17464	70.2	52	59.1	60.43	32	144.0	31.3	55.7
NE17544	77.5	54.6	74.9	69.00	3	145.3	36.0	58.2
NE17589	71.8	59.7	74.7	68.73	5	144.3	35.1	57.8
NE17561	74.3	63	71.4	69.57	2	144.7	35.6	58.3
NE17468	64.6	55.2	68.8	62.87	24	144.7	35.5	59.7
NE17474	47.3	56.9	71.9	58.70	35	144.4	35.6	57.4
NE17541	50.4	53.9	69.4	57.90	37	144.3	35.7	56.4
NE17534	75.2	56.5	67.9	66.53	9	144.1	31.2	57.1
NHH17447	68.9	61	67.2	65.70	12	145.3	33.4	57.4
NE17403	60.7	52.1	67.1	59.97	34	143.7	31.1	55.1
NE17629	69.7	54.3	66.1	63.37	22	144.0	34.7	57.6
NE17476	63.8	57.4	69.9	63.70	19	144.0	33.0	55.5
NE17611	69.6	53.5	62.8	61.97	28	145.0	32.7	55.6
NE17440	27	67.7	64	52.90	39	144.0	38.0	58.2
NHH17448	66.2	52.5	67.9	62.20	26	144.7	35.5	57.5
NE17463	56.7	59.7	67.6	61.33	31	144.4	34.1	55.7
NE16401	72.5	58.8	62.8	64.70	15	145.0	30.2	57.1
NE16552	32.4	59.7	61.5	51.20	40	144.7	42.5	58.6
NI17411	77.1	54.4	59.2	63.57	21	144.3	32.3	59.1
NI15711	71.2	57.4	59.4	62.67	25	144.0	30.3	54.2
NI17414	76.5	45	62.6	61.37	30	145.2	33.3	57.1
NE15420	79.3	49.3	64.7	64.43	17	145.3	30.9	58.0
WB CEDAR	73.6	45.8	61.1	60.17	33	144.3	29.4	56.8
LCS Valiant	73.3	58.5	70	67.27	8	145.3	32.9	56.9
CV	**10.58**	**9.43**	**8.3**			**0.33**		**0.85**
GRAND MEAN	**67.19**	**56.04**	**66.74**			**144.58**		**57.13**
LSD	**11.62**	**8.64**	**9.06**			**0.78**		**0.79**

The data for 2017 are:

	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 three-year averages for the lines tested in all three years (2017-2019) are below. Note very few lines were in common for all three years.

	Lincoln	N.Platte	Alliance	St. Avg.	Rank	Flowering	Height	Test Wt
	Yield	Yield	Yield	Yield		Date		
	bu/a	bu/a	bu/a	bu/a		D after	in.	lbs/bu
Name	yb_ln19	yb_np19	yb_al19	St. Avg.	St.Rank	jan. 1	HT In Avg.	TWT AVG
LCS Valiant	75.20	57.43	76.23	69.62	1	141.44	30.06	57.72
NE15420	74.87	45.70	66.50	62.36	2	141.43	30.18	57.33
NI17411	71.57	51.50	59.07	60.71	4	141.55	30.62	58.40
NI17414	71.60	50.57	64.00	62.06	3	141.52	31.79	57.18
WB CEDAR	67.13	47.10	64.93	59.72	5	139.97	27.34	56.80

The importance of the effort in irrigated wheat is that it provides us with a window into the highest yielding environments (basically lets us estimate yield potential), something that rainfed environments rarely do. Currently we are selecting lines on the basis of how we expect them to do under irrigation, testing them in the State Variety Trial and determining if our expectations are warranted. Perhaps the best example of approach is NE15420 which topped the irrigated trial in 2019, performed well in 2018, and has the best two year average. However as can be seen in dryland data above, it is a good dryland wheat, but there are better dryland wheat lines. 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?” In 2019, we decided to try a contract grower to determine if our lines do well under irrigation, but unfortunately that trial was lost to hail. We contracted with him again in 2019-2020.

4. Nebraska Intrastate Nursery:

In 2019, 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 (syn. Alliance). In addition, two replications at Lincoln were sprayed once with fungicides to control fungal disease, while two replications were not treated which allowed a comparison of fungal diseased vs. largely fungal disease free genotypes. Fungicides do not control bacterial or viral diseases. The fungal disease pressure was moderate in 2018. The sites at McCook and Hemingford were also sprayed with a single application of fungicide. McCook, Hemingford, and Lincoln fungicide treated were the three highest yielding locations indicating the benefits of fungicides across the state in 2019. At Lincoln, the untreated plots yielded 18% less than the fungicide treated plots (an average of 14.7 bu/a) in a year when disease was normal compared to previous years. Note the benefit of the fungicide application varied considerably with the line. Those lines having little benefit were disease resistant or disease tolerant. The lowest yielding site in Nebraska was Mead (due to winter injury) and then North Platte (which had some drought, some winter injury, and Cephalosporium stripe).

Data for 2019 are:

Variety or Exp. Line	Mead Yield Bu/a yb_m19	Linc.Int Yield Bu/a yb_lim19	Linc. Yield Bu/a yb_ln19	Clay Cent Yield Bu/a yb_cc19	N.Platte Yield Bu/a yb_np19	McCook Yield Bu/a yb_mc19	Grant Yield Bu/a yb_grd19	Sidney Yield Bu/a yb_s19	Alliance Yield Bu/a yb_al19	Average No Mead Bu/a	Rank No Mead	Flowering date D after Jan.1	Height inches	TestWt lbs/bu Gr +AL
CHEYENNE	15.8	38	31.9	36.5	50.3	80.4	66.2	52	55	51.29	60	149.89	35.40	59.54
Freeman	22.6	77.8	74.7	66.6	55	96.6	65.5	50.9	71.5	69.83	20	145.96	27.22	58.40
GOODSTREA	23.5	68.7	58.2	56	53.1	70.7	62.3	53.4	71.3	61.71	56	148.09	31.80	59.80
LCS Valiant	19.1	88	66.2	60.5	53.4	88.4	73.2	46.7	79	69.43	23	143.86	26.25	60.60
Siege	23.8	80.2	71.5	64.2	40.1	96.9	65.2	48.2	68.9	66.90	37	142.8	27.18	60.20
NE13515	19.8	72.5	60.8	63.5	49.6	80.3	50.8	56.5	81.7	64.46	50	147.74	29.53	59.80
NE14434	33.3	97	75.6	65.7	47.6	97.8	74.3	57.6	74.4	73.75	2	148.36	29.20	59.35
NE14494	18.9	79.6	53.5	63.9	51.2	93.3	66.6	51	79.4	67.31	35	148.29	28.98	59.85
NE14538	31.8	85	75.9	66.2	58.6	85.5	58.5	61.3	76.9	70.99	13	148.08	28.88	59.65
NE14691	30.2	84	72.7	62	54.1	77	53.7	52.7	65.9	65.26	46	148.04	28.27	58.75
NE14696	18.8	80.4	58.2	51.2	52.7	84.9	64.6	57.2	72.1	65.16	47	147.52	27.58	57.25
NE15410	16.5	78.4	52.9	58.6	47.9	102.7	72.5	52.6	81.2	68.35	30	144.06	28.92	59.45
NE15624	21.6	84.6	65.9	62.9	45.4	91.4	69.7	43.2	67.5	66.33	40	146.54	25.23	59.10
NE16424	23.2	81.6	73.3	52	41.1	101	78.1	61.7	79.6	71.05	12	144.02	26.23	60.30
NE16468	23	85.9	71.2	65.8	52.3	100.7	60.6	59.1	79.3	71.86	8	143.6	26.88	59.90
NE16562	29.4	93.1	84.5	72.6	41.2	90.5	48.2	60.5	84.6	71.90	7	142.82	27.07	58.80
NE16563V	17	77.4	59.9	60.1	53.4	88.4	66	52.8	59.7	64.71	49	148.07	25.92	58.85
NE16593	21.9	76.4	66.1	66.5	53.3	95.6	53.9	46.9	73.3	66.50	39	144.08	26.93	59.75
NE17415	22.4	78.8	73.2	55.9	34.8	78.5	59.7	53.4	74.4	63.59	51	140.87	26.78	58.30
NE17433	23.7	95.4	79.7	63.3	38.8	92.8	66.3	54.2	80.7	71.40	10	141	26.13	59.45
NE17441	21.7	97.1	85.3	63.8	41.2	93.6	67.8	50.4	77.4	72.08	5	143.88	28.65	60.30
NE17443	24.7	85	71.9	62.8	57.8	101.7	58.9	52.8	85.4	72.04	6	148.04	25.98	59.60
NE17452	17.5	68.4	53.5	62.3	39.1	90.7	72.8	41.4	69.2	62.18	52	147.66	26.58	58.70
NE17470	24.9	78.5	78	69.6	50.2	97.4	78.9	51.8	67.8	71.53	9	144.18	27.93	59.70
NE17483	20.5	75.7	70.5	61.5	32.5	77.1	52.8	50.4	76.4	62.11	53	143.08	27.17	60.10
NE17486	18.3	79.4	64	62	55.8	87.5	52.9	54	71.4	65.88	42	145.87	26.27	59.70
NE17506	28.8	67.7	64.7	62.8	46.8	75.9	55.6	55.7	66.9	62.01	54	147.79	30.60	59.40
NE17512	15.1	61.3	59.8	57.2	32.4	64.8	61.7	49.9	71.8	57.36	58	142.99	28.85	56.65
NE17524	18.8	72.4	57.9	63.3	62.5	87.7	65.9	56.7	80.9	68.41	29	147.91	27.97	59.75
NE17528	19.6	90.1	74	58.2	46.3	82.7	68.4	54.7	76.8	68.90	25	148.14	29.25	59.90
NE17544	30.4	85.3	68	71.1	48.3	89.5	77.3	65.6	78.6	72.96	4	147.9	29.27	59.70
NE17545	18.2	89.3	54.4	59.5	56.6	104.5	72.2	54.5	79.4	71.30	11	147.9	28.40	61.10
NE17561	33.2	83.4	78.2	59.7	50	81.6	65.3	56.3	73.7	68.53	26	146.02	29.80	60.35
NE17563	20.9	79.9	57.9	65.6	57.3	93.3	68.1	58.5	67.3	68.49	27	147.96	27.85	59.60
NE17576	21.1	80.2	66.4	59.5	68.7	84.4	76.9	54.7	76.5	70.91	14	148.18	31.15	59.90
NE17578	20	86.9	74.4	59.5	39.3	79.1	67.4	45.9	70.6	65.39	44	147.7	28.62	59.95
NE17589	25.5	94.6	76.5	69.1	55.2	97	63.6	57.6	81	74.33	1	146.63	29.08	59.65
NE17590	34.4	87.6	69.5	67	38.7	94.4	69.9	55.3	78.2	70.08	19	147.75	29.60	57.75
NE17608	22.1	82.7	62.1	68.7	44.5	90.3	55.7	60.2	64	66.03	41	146.46	26.38	59.80
NE17614	14.2	79.8	56.2	50.4	39.1	72.1	54.6	54.8	69.6	59.58	57	145.92	27.30	58.90
NE17616	17.6	67.7	52.6	56.2	46.8	79.2	64	63.8	65.1	61.93	55	148.95	30.48	59.80
NE17662	36.8	87.3	82.1	69.1	38.7	84.7	61.2	51.2	65.8	67.51	34	147.87	28.75	60.20
NH144913-3	22.3	71.5	67.5	63.5	66.6	86.4	57.6	58.6	76	68.46	28	143.93	28.07	56.70
NHH17450	20.3	88	68.2	66.6	54.9	83.8	97	51.3	74.1	72.99	3	143.84	26.82	60.00
NHH17503	18.2	76.4	62.9	66	42.5	88.8	74.1	50.1	76.5	67.16	36	148.24	27.32	62.00
NHH17612	24.1	94	68.1	60.7	66.6	89	67.3	55.7	62.4	70.48	17	147.89	27.03	60.35
NI12702W-4	20.2	76.6	66.1	65.5	53.5	93.9	64.7	55	83.1	69.80	21	145.99	28.30	59.55
NI13706	18.5	82.1	66.6	64.5	57.7	87	73.8	61.5	73.1	70.79	15	149.11	29.87	60.05
NI17410	25.5	92.3	88.5	61.7	40.2	88.5	64.9	55.3	73.7	70.64	16	144.16	28.00	60.75
NW13493	30.8	88.2	76.2	65.6	45.5	89.2	72.6	50	73.8	70.14	18	145.8	27.75	60.15
NW13570	28.3	88.6	77.2	60.2	40.3	91	72.1	47.9	57.3	66.83	38	148.79	27.83	59.94
NW15443	22.5	89.5	68.5	62.5	55.9	88	58.5	50.9	68.9	67.84	31	147.86	29.22	59.20
NW17620	21.5	77.7	63.5	59.2	52.2	89.6	59	50.7	70.5	65.30	45	148.26	27.93	62.40
NW17627	33.6	77.5	76.8	61.9	38.5	88.8	78.8	62.6	70.2	69.39	24	147.76	28.38	59.00
OVERLAND	24.1	75	70	66.6	39.4	86.9	75.1	57.4	69.9	67.54	33	148.12	28.57	59.50
Panhandle	18.2	82	54.2	57.9	48.4	84.8	61.1	56.9	74	64.91	48	147.73	32.15	58.95
PSB13NEDH-1	21	89.8	58.9	56	59	99.9	64	50.5	78.2	69.54	22	147.57	28.80	60.20
Robidoux	14.6	92.6	46.1	54.3	45.3	97.2	87.6	47.8	71.6	67.81	32	147.85	28.07	59.05
Ruth	17.4	89.3	52.6	62.4	40.5	88.5	55.9	53.6	80.8	65.45	43	147.77	27.85	60.10
SCOUT66	20.9	50.2	45.3	51.9	40.6	71	64.3	54.5	60.5	54.79	59	147.84	32.37	59.29
Average:	**22.71**	**81.07**	**66.35**	**61.67**	**48.49**	**88.25**	**65.94**	**53.97**	**73.08**	**67.35**		**146.52**	**28.34**	**59.58**

In 2019 Nebraska Intrastate Nursery (NIN) advance wheat, 52 wheat cultivars were analyzed for kernels characteristics, milling performances, ash and protein contents, dough rheological and bread making properties.

There were significant differences in kernel characteristics among these cultivars. The kernels hardness indexes were 62.8±6.6. 3/4 samples had high hardness (≥ 60.0) including Robidoux, Panhandle, Goodstreak, Ruth, Scout66, and Cheyenne checks, and the rest of samples had low hardness (< 60) including Freeman check. 47 samples were classified as HARD, and the rest of samples were classified as MIXED. The kernels diameters and weights were 2.6±0.1 mm and 31.7±2.1 mg, respectively. All samples had large kernels diameter (> 2.4 mm) including the checks, and most (83%) samples had large weight (≥ 30.0 mg) including all checks. About than half (48%) samples had small kernels hardness variances (σ ≤ 17), and All samples had small kernels diameters deviation (σ ≤ 0.4), but most (96%) samples had big kernels weights variability (σ > 8). Therefore, the kernels were diverse in weight and hardness.

There were significant differences in milling performances among these cultivars. The flour, bran and short yields were 72.9±0.9%, 34.2±1.7%, and 3.1±0.5%, respectively. All samples got high flour yield (>70.0%) including the checks. The bran, short and milling rates were 3.7±0.5, 3.3±0.6, and 3.3±1.1, respectively. Most samples got fair or better bran cleaning and milling performance. The kernels hardness indexes were significantly positively correlated with short yields, bran cleaning and milling performances as well as wheat protein and ash contents. The kernel diameters were significantly positively correlated with kernel weights, and short yields. In addition, the flour yields were significantly positively correlated with bran cleaning and milling performances as well as wheat protein contents, and negatively with brain yields. The bran yields were significantly negatively correlated with bran cleaning and milling performances as well as wheat protein contents. The short yields were significantly positively correlated with ash contents and negatively with short cleaning rates. The bran cleaning rates were significantly positively correlated with short cleaning and milling performance rates as well as wheat protein contents. The short cleaning rates were significantly positively correlated with milling performance rates.

There were significant differences in ash and protein contents respectively among these flour samples. The ash contents of white flour (WF) at 14% mb were 0.44±0.05%. Most (88%) flour samples had low ash content (< 0.50%) excluding Goodstreak check. The protein contents of whole wheat (WW) at 12% mb were 14.0±0.7%. All samples had high protein contents in WW (> 12.0%) including the checks. The protein contents of WF at 14% mb were 12.2±0.8%. All samples had high (> 10.0%) protein contents in WF including the checks. Both WW and WF protein contents were significantly correlated each other. After milling, protein contents were lost 2.2±0.4%. Some samples got high protein losses (> 2.0%). The falling number (FN) of WF at 14% mb were 458±39 sec. All flour samples had high FN (> 350 sec) including the checks.

There were significant differences in dough rheological properties among these flour samples. The flour water absorptions (abs) at 14% mb were 63.4±1.4%. All flour samples had high water abs (> 60.0) including the checks, and 87% samples had water abs ≥ 62.0%. The peak times (PT) were 5.5±1.4 min. Most (65%) samples had good dough extensibility (3.0-6.0 min) including Freeman, Robidoux, Panhandle, Ruth, Scout66, and Cheyenne checks, 4% samples had small extensibility (< 3 min) including Goodstreak check, and the rest of samples had much large dough extensibility (≥ 6.0 min). The peak torques (PQ) were 44.5±2.9 %TQ. 42% samples had strong dough (≥ 45.0 %TQ) including Goodstreak, Scout66, and Cheyenne checks, and the rest of samples had less strong dough (< 45.0% TQ) including Freeman, Robidoux, Panhandle, Ruth checks. The total area (TA) of mixing resistances were 120±20 %TQ·min. The mixing tolerance rates (TR) were 4.4±1.1, respectively. Both TA and TR were strongly significantly correlated each other. Most (92%) samples had strong dough mixing resistance (TA ≥ 100 %TQ·min), and 90% samples got fair or better than fair mixing tolerance, excluding Goodstreak check.

There were significant differences in bread-making properties among these flour samples. The baking water abs at 14% mb were 63.5±1.3%. All samples had high water abs (≥ 60.0%) including the checks, and 87% samples had water abs ≥ 62.0%. The mixing time (MT) were 6.1±1.7 min. Half samples had normal MT (3.0-6.0 min) including Panhandle, Goodstreak, Scout66 and Cheyenne checks, and the rest of samples had much long MT (≥ 6.0 min) including Freeman, Robidoux , and Ruth checks. The dough performance rates were 3.8±0.3. The loaf volumes (LV) and specific volumes (SV) were 888±52 cc and 6.3±0.4 cc/g, respectively. Most (83%) samples had LV ≥ 850 cc or SV ≥ 6.0 cc/g including Robidoux , Panhandle, Goodstreak, Ruth, Scout66, and Cheyenne checks. Most samples had good crumb structures and texture. The overall bread rates were 4.1±0.4. All samples had fair or better bread quality including the checks, and most (65%) samples had good or better bread quality including Robidoux , Panhandle, Goodstreak, Ruth, Scout66, and Cheyenne checks.

The wheat flour protein contents significantly affected on dough rheological properties, which impacted on final bread quality. For details, the flour protein contents were significantly positively correlated with falling numbers, water abs, dough strengths, loaf volumes and bread rates, and negatively with dough extensibility. In addition, the flour ash contents were significantly positively correlated with falling numbers and water abs. The flour water abs were significantly correlated positively with dough strengths, baking water abs, loaf volumes and bread rates, and negatively with dough extensibility. The dough extensibility was significantly positively correlated with dough resistances or tolerances to mixing, and mixing times, and negatively with dough strengths, loaf volumes. The dough strengths were significantly positively correlated with dough mixing resistances, baking water abs, loaf volumes and bread rates. The dough mixing resistances and tolerances were significantly positively correlated with mixing times. The baking water abs were significantly positively correlated with loaf volumes and bread rates. The loaf volumes and specific volumes were significantly positively correlated with bread rates.

In 2018, 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 (lost to severe storms the day we began harvesting the site) , and Hemingford (syn. Alliance).

The 2018 data are:

	Mead	Linc IM	Lincoln	Benefit	C.Center	N.Platte	McCook	Grant	Aliiance	NEAvg.	Rank	Kansas	Rank	Average	Rank	Heading	Height	test Wt.
	Yield	Yield	Yield	Of	Yield	Yield	Yield	Yield	Yield			Yield		Yield				
Name	bu/a	bu/a	bu/a	Fungicide	bu/a	bu/a	bu/a	bu/a	bu/a			bu/a		bu/a				
	yb_m18	yb_lim18	yb_ln18	%	yb_cc18	yb_np18	yb_mc18	yb_grd18	yb_al18			yb_ks18						
NE16562	59.6	84.0	83.2	101.0	73.8	66.4	73.9	95.2	64.8	75.1	1	46.9	5	72.0	1	144.00	26.33	57.67
NE14691	60.2	85.1	78.5	108.4	77.9	52	65.7	86.6	54.5	70.1	2	42.9	23	67.0	2	146.00	27.70	58.70
NE16593	60.0	84.5	81	104.3	70.4	66	60.5	71.9	61.2	69.4	3	41.1	40	66.3	4	145.00	27.29	59.37
NE16468	55.7	90.9	76.6	118.7	69.0	64	57.6	73.9	65.9	69.2	4	40.2	46	66.0	6	145.50	26.25	57.83
NE16424	55.8	81.3	78.1	104.1	73.2	62.7	63.5	73.7	65.3	69.2	5	44.7	13	66.5	3	145.50	25.23	57.93
NE16593	58.9	69.9	70.1	99.7	69.9	61.7	69.5	84.7	66.7	68.9	6	43.6	19	66.1	5	144.50	27.49	58.47
NE14494	50.4	86.8	78.7	110.3	68.9	55.3	62.4	79.5	65.9	68.5	7	44.6	14	65.8	7	144.00	28.29	59.20
LCS Valiant	56.8	77.0	72.5	106.2	62.7	59.1	69.9	82.9	65.6	68.3	8	41.6	31	65.3	11	144.50	26.31	58.60
NE14696	58.9	75.5	74.6	101.2	66.4	60.3	66.3	83.0	60.5	68.2	9	46.5	8	65.8	9	145.00	28.93	57.87
NI13706	52.4	84.4	76.6	110.2	67.8	54.9	63.6	78.2	67.5	68.2	10	37.8	55	64.8	14	144.50	25.41	57.47
PSB13NEDH-14-83W	49.1	86.8	79.7	108.9	56.9	61.3	63.0	85.4	62.7	68.1	11	47.4	2	65.8	8	146.00	27.66	58.57
NE16402	49.0	80.3	72.9	110.2	61.5	62.5	62.2	92.8	62.4	68.0	12	44.1	17	65.3	12	145.50	27.15	58.73
NI17410	57.5	81.9	75.7	108.2	69.1	54.4	62.8	76.2	64.1	67.7	13	47.0	4	65.4	10	145.00	27.91	58.80
NE13604	55.0	72.6	75.2	96.5	65.9	60.1	66.3	83.0	62	67.5	14	39.0	50	64.3	17	145.50	27.11	58.60
NW13570	55.5	79.5	79.9	99.5	62.5	55.2	75.0	79.2	52.9	67.5	15	44.8	12	64.9	13	144.00	27.00	58.20
NE16451	55.4	75.2	74.1	101.5	70.1	58.7	65.8	70.9	66.7	67.1	16	38.8	52	64.0	20	145.50	26.39	56.53
NE15420	58.2	83.6	72.9	114.7	62.2	56.8	64.1	76.9	61.4	67.0	17	44.5	16	64.5	15	145.00	24.34	58.07
NE14531	55.8	79.1	74.7	105.9	65.7	58.2	57.8	84.0	59.8	66.9	18	41.9	29	64.1	19	144.50	28.13	58.53
NW15443	60.8	86.5	67.1	128.9	71.9	53.9	66.0	69.7	59.1	66.9	19	45.6	10	64.5	15	147.50	28.59	56.97
NE15624	56.8	76.7	73.7	104.1	65.3	65.4	64.3	66.8	61.7	66.3	20	36.7	57	63.0	24	145.00	25.13	57.43
NE13515	52.6	81.2	72.1	112.6	62.1	54.1	62.7	83.0	62.7	66.3	21	36.3	58	63.0	27	144.50	27.01	58.80
NE16634	54.7	86.8	73	118.9	64.8	59.4	66.2	64.4	59.8	66.1	22	38.3	53	63.0	25	146.00	28.03	58.80
NW13493	56.9	71.7	72.3	99.2	70.1	50.1	70.1	79.2	58.5	66.1	23	50.1	1	64.3	18	146.00	27.26	58.90
Robidoux	43.6	81.6	70.5	115.7	70.6	53.1	66.5	77.7	64.5	66.0	24	38.9	51	63.0	26	144.50	26.81	57.93
NE16412	51.2	66.7	61.1	109.2	68.6	65.6	68.3	81.6	64.6	66.0	25	37.0	56	62.7	33	146.50	27.00	57.47
NE16443	43.1	77.9	69.8	111.6	57.2	58.7	67.1	86.0	67.6	65.9	26	41.5	34	63.2	22	144.00	26.84	57.23
NE16659	49.3	78.1	73.3	106.5	60.2	63.7	65.1	78.5	58.5	65.8	27	43.9	18	63.4	21	145.50	27.11	56.80
NE14538	51.7	73.3	76.3	96.1	64.2	62.4	57.2	77.7	62.7	65.7	28	42.0	28	63.1	23	144.50	28.81	58.23
NE15410	53.7	66.2	55.5	119.3	60.8	68.5	70.1	82.8	66.6	65.5	29	39.1	49	62.6	36	144.50	28.13	57.83
Overland FHB-10	58.3	75.3	73.6	102.3	67.2	51.4	64.5	76.8	57.1	65.5	29	42.6	26	63.0	27	144.50	28.93	58.90
NI12702W	51.4	79.8	73.2	109.0	57.9	66.1	64.5	75.2	55.5	65.5	31	40.8	44	62.7	35	145.50	27.23	59.30
NE14421	49.7	71.7	75.8	94.6	62.0	62	64.3	72.9	64.6	65.4	32	41.6	31	62.7	34	144.00	25.85	58.03
NE15571	52.1	73.3	74.1	98.9	56.3	58.2	59.9	83.5	65.3	65.3	33	43.2	22	62.9	31	144.00	27.03	57.20
OVERLAND	57.7	79.1	72.4	109.3	71.8	48.5	62.0	67.8	62.5	65.2	34	44.6	14	62.9	29	145.50	27.98	59.03
NE14606	52.3	72.8	68.9	105.7	70.1	60.1	59.9	79.3	57.4	65.1	35	41.8	30	62.5	37	145.50	26.79	58.20
NE16563V	52.2	79.4	78.9	100.6	59.4	57.5	57.6	70.4	63.6	64.9	36	46.7	6	62.9	32	146.00	25.84	56.10
Ruth	49.7	81.7	72.4	112.8	51.4	55.4	63.8	80.8	63.7	64.9	37	47.2	3	62.9	30	145.00	27.30	58.53
GOODSTREAK	58.3	70.5	75.1	93.9	62.6	58	59.1	78.6	55.2	64.7	38	41.3	36	62.1	39	145.50	30.89	58.63
NE13434	59.1	78.9	71.6	110.2	56.0	55.5	65.5	68.1	59.5	64.3	39	45.5	11	62.2	38	145.50	27.93	58.43
NH144913-3	49.8	76.9	68.1	112.9	61.6	66.2	67.8	70.2	53.1	64.2	40	41.6	31	61.7	42	145.00	26.28	54.90
NE16578	52.5	76.8	64.3	119.4	58.1	59.1	68.2	72.6	62	64.2	41	43.6	19	61.9	40	144.50	27.38	56.17
NE16467	45.5	73.6	69.7	105.6	60.2	63.6	58.3	81.8	59.9	64.1	42	41.1	40	61.5	43	145.00	27.76	56.83
NE16587	52.1	78.6	70.2	112.0	58.5	57.3	61.9	74.4	57.8	63.9	43	40.8	44	61.3	44	144.50	25.81	58.27
NI17409	58.0	75.4	71.4	105.6	66.9	50.5	52.0	71.8	63.7	63.7	44	46.6	7	61.8	41	145.50	26.26	58.60
NI14729	45.1	75.7	64.1	118.1	64.5	53.7	64.3	77.3	63.3	63.5	45	41.3	36	61.0	46	146.00	27.29	56.50
NI15713	41.9	80.3	67.3	119.3	63.8	56.3	61.1	78.3	57.5	63.3	46	41.3	36	60.9	47	145.50	26.63	57.40
Panhandle	49.1	75.4	68.8	109.6	68.7	51.9	66.2	72.8	51.3	63.0	47	41.4	35	60.6	49	145.00	29.60	57.40
Freeman	48.9	65.2	65.1	100.2	57.2	58.5	65.6	80.6	62.9	63.0	48	42.1	27	60.7	48	145.50	26.65	57.40
NE16631	48.4	74.2	73	101.6	51.0	53.2	55.0	78.6	70.5	63.0	49	46.1	9	61.1	45	145.00	28.09	58.67
Siege	56.1	73.8	66.8	110.5	62.5	54.2	56.3	76.9	56.1	62.8	50	38.0	54	60.1	51	147.00	26.29	58.53
NE14434	38.8	73.5	76.6	96.0	53.4	59	61.2	73.9	64.6	62.6	51	42.9	23	60.4	50	147.50	27.66	57.57
NE16579	56.0	57.6	61.4	93.8	55.3	50.1	63.7	82.5	65	61.5	52	42.9	23	59.4	52	145.00	26.59	57.33
NI14722	45.1	62.3	65.5	95.1	59.3	48.4	64.3	78.1	64.7	61.0	53	34.1	59	58.0	54	145.50	25.39	59.17
NW15573	54.9	72.5	63.1	114.9	53.2	53	62.5	70.3	54.7	60.5	54	43.6	19	58.6	53	144.50	26.36	58.70
NI17417	54.5	73.4	69.7	105.3	61.2	38.6	53.6	73.7	54.6	59.9	55	25.3	60	56.1	58	145.50	25.95	59.10
NI13717	51.3	76.4	73.9	103.4	43.4	53.9	49.7	75.2	53.5	59.7	56	41.3	36	57.6	55	145.00	27.25	56.63
NW15404	53.8	67.4	66	102.1	51.7	50.7	59.9	64.2	59.7	59.2	57	41.0	42	57.2	56	145.00	26.21	57.57
NE16552	52.2	87.8	45.3	193.8	45.9	58	49.8	69.6	57.2	58.2	58	41.0	42	56.3	57	146.00	32.45	58.63
SCOUT66	46.6	48.0	48.3	99.4	56.1	46.8	54.4	68.0	57.8	53.3	59	39.6	47	51.7	59	145.00	31.64	59.27
CHEYENNE	46.9	48.7	57.3	85.0	58.8	44.5	46.7	63.8	49.9	52.1	60	39.5	48	50.7	60	145.50	31.95	58.27
GRAND MEAN	**52.78**	**76.02**	**70.86**		**62.6**	**57.08**	**62.62**	**76.89**	**61.01**	**65.0**		**41.95**				**145.20**	**27.35**	**58.00**
LSD	**11.89**	**11.91**	**11.23**		**9.76**	**11.88**	**13.41**	**13.84**	**9.81**			**6.08**						
CV	**11.63**	**6.44**	**6.52**		**8.05**	**8.56**	**8.81**	**7.4**	**8.31**			**8.92**						

In 2018 Nebraska Intrastate Nursery (NIN) advance wheat, 51 wheat cultivars or lines were analyzed for kernel characteristics, milling performances, ash and protein contents, dough rheological and bread making properties.

The wheat properties tested results were shown in Table 1. There were significant differences in kernel characteristics among these cultivars. The kernel hardness indices were 51.5±9.7. Only 18% samples had high hardness (60.0-70.0), the rest of samples had low hardness (< 60) including Goodstreak, Ruth, Overland, and Freeman checks. 18 samples were classified as HARD, 31 samples were classified as MIXED, and the rest of samples were classified as SOFT. The kernel diameters and weights were 2.6±0.1 mm and 31.6±2.7 mg, respectively. Almost all (98%) samples had large kernels diameter (>2.4 mm) including all checks, and most (71%) samples had large weight (≥ 30.0 mg) including Ruth, Overland, and Freeman checks. Most (55%) samples had small kernel hardness variances (σ < 17), and almost all (98%) samples had small kernels diameters deviation (σ < 0.4), but most (73%) samples had big kernel weights variability (σ ≥ 8). Therefore, the kernel were very diverse in weight.

Table 1. Wheat Properties and Correlation [a]

N = 51	hard	d	wt	flrYld	brnYld	shrtYld	bran	short	mill	whtPro	flrPro	flrAsh
Mean	51.47	2.63	31.60	71.20	26.34	2.46	3.17	2.91	2.62	14.31	11.85	0.40
Std Dev	9.71	0.10	2.72	1.87	1.98	0.61	0.93	0.94	1.14	1.27	0.69	0.04
Min	14.17	2.34	26.05	60.91	23.45	0.23	0.50	0.50	0.50	11.48	10.50	0.34
Max	68.43	2.86	39.35	73.65	37.22	4.38	4.50	4.50	4.50	16.74	13.53	0.53
hard	1.0000	-0.1425	-0.2282	**0.5025**	**-0.6296**	**0.5058**	**0.6654**	***0.2783***	**0.5702**	-0.1410	0.1278	**0.5411**
d		1.0000	**0.8922**	0.1641	-0.1341	-0.0672	0.0579	0.1590	-0.0164	**0.3417**	**0.3417**	0.1737
wt			1.0000	0.0792	-0.0587	-0.0520	-0.0013	0.1061	0.0496	***0.3215***	***0.3311***	0.0969
flrYld				1.0000	***-0.9516***	0.0247	***0.6216***	***0.5416***	***0.4898***	-0.1516	0.0655	**0.3366**
brnYld					1.0000	**-0.3307**	**-0.7021**	**-0.4532**	**-0.5412**	0.1012	-0.1209	***-0.4428***
shrtYld						1.0000	***0.3758***	-0.1884	0.2568	0.1356	0.1912	***0.4070***
bran							1.0000	***0.4106***	***0.7520***	0.0904	0.2048	***0.5085***
short								1.0000	***0.4930***	0.1105	-0.0614	0.1192
mill									1.0000	-0.1157	0.0627	**0.4699**
whtPro										1.0000	***0.6495***	0.1071
flrPro											1.0000	0.2660
flrAsh												1.0000

a. Significantly correlated (correlation efficiency r) at p-value < 0.01 (bold) or < 0.05 (italic)

There were significant differences in milling performances among these cultivars. The flour, bran and short yields were 71.2±1.9%, 26.3±2.0%, and 2.5±0.6%, respectively. Almost all (98%) samples got high flour yield (≥ 68.0%). The bran, short and milling rates were 3.2±0.9, 2.9±0.9, and 2.6±1.1, respectively. Most samples got fair or better than fair bran cleaning and milling performance.

The kernel hardness indexes were significantly positively correlated with flour and short yields, bran cleaning and milling performances as well flour ash contents, and negatively correlated with bran yields. The kernel diameters were significantly positively correlated with kernel weights and wheat and flour protein contents. Both kernels diameters and weights were significantly positively correlated with wheat and flour protein contents.

In addition, the flour yields were significantly positively correlated with bran cleaning and milling performances as well as flour ash contents, and negatively correlated with bran yields. The bran yields were significantly negatively correlated with short yields, bran cleaning and milling performances as well as flour ash contents. The short yields were significantly positively correlated with bran cleaning rates and flour ash contents. The bran rates were significantly positively correlated with short and milling rates as well as flour ash contents. The short rates were significantly positively correlated with milling rates. The milling rates were significantly positive with flour ash contents.

The flour properties tested results were shown in Table 2. There were significant differences in ash and protein contents respectively among these flour samples. The ash contents of white flour (WF) at 14% mb were 0.40±0.04%. Almost all (98%) flour samples had low ash content (< 0.50%) including all checks. The protein contents of whole wheat (WW) at 12% mb were 14.3±1.3%. Almost all (94%) samples had high protein contents in WW (≥ 12.0%) including all checks. The protein contents of WF at 14% mb were 11.9±0.7%. All samples had high (≥ 10.0%) protein contents in WF including all checks. Both WW and WF protein contents were significantly correlated each other. After milling, protein contents lost 2.1±1.1%. Some samples had high protein losses (> 2.0%). The falling number (FN) of WF at 14% mb were 369±102sec. Most (66%) flour samples had high FN (≥ 350 sec) including all checks.

There were significant differences in dough rheological properties among these flour samples. The flour water absorptions (abs) at 14% mb were 63.3±1.8%. Most (76%) flour samples had high water abs (≥ 62.0) including Goodstreak, Ruth, and Overland, checks. The peak times (PT) were 6.8±2.1 min. Only 37% samples got good dough extensibility (3.0-6.0 min) including Goodstreak and Overland checks, and the rest of samples got much larger dough extensibility (≥ 6.0 min) including Ruth and Freeman checks. The peak torques (PQ) were 46.2±2.8 %TQ. Most (69%) samples got strong dough (≥ 45.0 %TQ) including Goodsreak and Ruth checks, and the rest of samples got less strong dough < 45.0% TQ) including Overland and Freeman checks. The total areas (TA) were 122±18 %TQ·min and tolerance rates (TR) were 4.4±0.8, respectively. Both TA and TR were significantly correlated each other. Most (84%) samples got strong dough resistance for mixing (TA ≥ 100 %TQ·min), and almost all (98%) samples got fair or better than fair mixing tolerance including all checks.

There were significant differences in bread-making properties among these flour samples. The baking water abs at 14% mb were 62.8±1.2%. Most (88%) flour samples got high water abs (≥ 62.0%) including all checks. The mixing time (MT) were 7.7±2.3 min. Only 25% flour samples got normal MT (3.0-6.0 min) including Goodsreak and Overland checks, and the rest of samples got much longer MT (≥ 6.0 min) including Ruth and Freeman checks. The dough performance rates were 3.8±0.3. The weight losses were 18.4±0.6%. The bread areas were 110±4 cm^2. The loaf volumes (LV) and specific volumes (SV) were 920±46 cc and 6.5±0.3 cc/g, respectively. Almost all (98%) samples got LV ≥ 850 cc or SV ≥ 6.0 cc/g including all checks. After stored overnight, the bread crumb firmness and brightness were 2921±389 Pa and 147±3, respectively. The cell numbers, diameters, non-uniformity and elongation were 6564±213 2.0±0.1 mm, 4.7±3.7 and 1.49±0.01, respectively. Most samples had good crumb structures and texture. The overall bread rates were 4.1±0.4. Almost all (98%) samples got fair or better than fair bread quality including all checks, and most (77%) samples got good or better bread quality including Ruth and Freeman checks.

The wheat flour protein contents significantly affected on dough rheological properties, which impacted on final bread quality. For details, the WF protein contents were correlated significantly positive with falling numbers, water abs, dough strengths, dough performance ratings, and loaf volumes, and negative with mixing times, crumb firmness and elasticities, and cell non-uniformity.

In addition, the WF ash contents were correlated significantly positive with water abs, and dough strengths, and negative with crumb firmness and elasticities. The WF falling numbers were correlated significantly positive with water abs, and negative dough extensibility and mixing times. The WF water abs were correlated significantly positive with baking water abs, dough performance ratings and weight losses, and loaf volumes, and negative with mixing times, crumb firmness and elasticities, crumb brightness, and cell non-uniformity. The dough extensibility was correlated significantly positive with mixing times, and negative with dough strengths, loaf volumes and areas, cell numbers and diameters as well as non-uniformity. The dough strengths were correlated significantly positive with dough resistances and tolerances, baking water abs, and loaf volumes, and negative with mixing times, crumb firmness and elasticities. The dough tolerances were correlated significantly positive with mixing times and bread ratings. The baking water abs were correlated significantly positive with dough ratings, weight losses, loaf volumes and areas, cell numbers and elongations as well as bread ratings, and negative with mixing times, crumb firmness and elasticities, crumb brightness, and cell non-uniformity. The mixing times were correlated significantly positive with crumb brightness, and negative with loaf volumes and areas, and cell numbers and diameters. The dough ratings were correlated significantly positive with cell elongation and bread ratings, and negative with cell non-uniformity. The weight losses were correlated significantly positive with loaf specific volumes, and cell elongations, and negative with crumb brightness. The loaf volumes or specific volumes or bread areas were correlated significantly positive with cell numbers and diameters as well as bread ratings, and negative with crumb firmness. The crumb firmness or elasticities were correlated significantly positive with cell diameters, and negative with bread ratings. The crumb brightness was correlated significantly negative with cell non-uniformity and elongations. The cell numbers were correlated significantly positively correlated with bread ratings. The cell non-uniformity were significantly negatively correlated with bread ratings.

The 2017 data are:

Name	Mead Yield Bu/a	Linc. IM Yield Bu/a	Lincoln Yield Bu/a	C Center Yield Bu/a	N. Platte Yield Bu/a	McCook Yield Bu/a	Grant Yield Bu/a	Sidney Yield Bu/a	Alliance Yield Bu/a	**Average Yield Bu/a**	**Rank**
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		

Data from 2017 to 2019 (three year average) from the Nebraska Intrastate Nursery for grain yield (bu/a) are presented below:

	Mead	Linc.Int	Linc.	Clay Cent	N.Platte	McCook	Grant	Sidney	Alliance	State	
Variety	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Average	
or	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	
Experimental Line	yb_m19	yb_lim19	yb_ln19	yb_cc19	yb_np19	yb_mc19	yb_grd19	yb_s19	yb_al19		rank
CHEYENNE	35.83	39.43	38.63	49.20	49.57	62.60	54.33	50.70	49.90	49.17	24
Freeman	47.73	71.30	69.43	63.33	61.00	86.63	66.93	58.80	68.70	67.89	14
GOODSTREAK	47.20	68.07	59.13	57.90	53.30	67.20	59.27	54.35	62.10	60.52	22
LCS Valiant	47.63	84.83	71.33	64.10	59.00	85.10	70.57	59.85	70.53	70.28	2
Siege	47.40	78.73	72.80	67.53	51.70	80.40	65.83	54.00	62.43	66.46	19
NE13515	44.00	75.90	68.33	65.63	55.83	80.57	63.93	58.45	68.00	66.46	18
NE14434	47.47	87.27	79.03	61.70	60.80	85.57	61.83	60.70	69.77	69.81	5
NE14494	46.33	81.17	65.40	69.33	57.50	86.50	63.63	55.65	71.67	68.62	8
NE14538	45.07	82.20	73.77	65.63	66.50	78.27	61.07	57.10	63.77	67.70	15
NE14691	49.20	85.30	74.40	73.07	58.83	77.00	64.00	53.95	59.20	68.00	13
NE14696	48.67	74.53	62.17	61.93	58.37	84.63	64.97	58.55	66.97	66.61	17
NE15410	47.10	74.70	55.13	62.40	61.23	92.23	69.23	60.35	72.97	68.26	11
NE15624	52.40	84.30	73.87	68.07	59.30	84.37	64.30	55.45	69.33	69.99	4
NHH144913-3	45.37	77.83	64.83	62.43	66.60	85.17	57.93	62.25	64.37	66.98	16
NI13706	48.07	82.17	76.47	66.43	63.10	77.80	70.80	60.05	71.30	70.70	1
NW13493	51.57	74.33	74.33	68.90	57.60	87.37	69.37	59.10	66.43	69.38	6
NW13570	48.37	82.80	72.40	66.77	55.03	88.23	70.17	57.20	57.17	68.27	10
NW15443	48.50	87.63	68.50	67.83	60.40	85.03	58.67	53.90	63.40	68.14	12
OVERLAND	48.50	74.87	64.53	69.13	47.83	79.80	62.03	58.95	65.37	65.29	20
Panhandle	40.23	74.57	55.13	60.93	50.17	78.13	61.20	60.50	59.57	61.87	21
PSB13NEDH-14-83W	49.20	87.70	65.53	58.93	65.37	86.73	67.83	57.55	72.80	70.15	3
Robidoux	44.17	88.03	60.43	65.57	55.23	86.23	73.13	56.25	70.13	68.91	7
Ruth	45.23	87.37	68.50	63.80	52.90	87.87	62.20	58.05	71.03	68.36	9
SCOUT66	40.43	48.13	43.73	52.70	46.03	62.97	57.53	52.35	57.37	52.54	23

As can be seen from the excellent three-year yields of recently released lines (LCS Valiant, Ruth, Robidoux, Siege, 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. NI13706 has excellent yield and is actually a good anther extruder as would be needed in hybrid wheat, but its end-use quality is not good enough to warrant release. As expected, Cheyenne and Scout 66 were the lowest yielding lines. The other taller wheat lines Goodstreak and Panhandle, also did not do well across the state, but have their niche in areas where plant height and straw are needed. Both broadly and more narrowly adapted lines have value in wheat production, and we breed for both.

5. <u>Nebraska Triplicate Nursery (NTN):</u>

The same comments about the NIN data apply to the NTN. Sidney was lost to storms before we could harvest the nursery. It was interesting to look at the three check lines in this nursery. Freeman had a ba d year mainly due to severe shattering in eastern Nebraska (something not previously seen). Ruth had a good year, and Goodstreak did remarkably well for a tall wheat. A number of experimental lines did very well and were superior to Ruth. Note, any test weight that was less than 50 lbs/bu was due to a location where the grain yield was too low to measure the test weight on our new combine. We purchased a new combine and decided not to put in the smaller weigh cell as it slows the harvest operation. Hence test weight in adverse conditions will be very low (the weigh cell is not full). We view this as a small price to pay for better efficiency. Also, lines with low yield are generally not advanced. Of course, some low yields are due to planting issues.

The data for 2019 are:

Variety	Mead	Linc.	ClayCen	NorthPlat	McCook	Grant	sideny	Alliance	State AVG		State AVG	State AVG	State AVG
or	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	RANK	Height	Moist	Testwt
Experimental	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a		(in)	%	lbs/bu
Line	yb_m19	yb_ln19	yb_cc19	yb_np19	yb_mc19	yb_grd19	yb_s19	yb_al19	No Mead				
NE18412	23.6	68.8	72.7	62	83.9	72.4	66	83.1	72.70	1	33.90	11.47	59.10
NE18583	27.1	76.1	56.5	58.9	83.1	79	57.5	89.6	71.53	2	36.50	11.47	58.65
NE18469	19	71.3	66.5	61.7	82.9	73.6	59.3	72.8	69.73	3	36.13	11.27	58.40
NE18434	26	74.9	65.6	61.1	82.8	77.2	42.7	82.8	69.59	4	31.93	11.10	58.50
NE18640	30.8	76.4	54.4	64.8	80	66.9	56.9	79.4	68.40	5	35.90	13.07	65.10
NE18573	25.4	65.8	59.4	56.5	78.6	82.7	58.8	76.7	68.36	6	37.05	12.30	57.85
NE18509	21.2	74.3	61	65	82.3	61	49.6	84.7	68.27	7	35.38	11.93	60.45
NE18630	25.5	71.6	62.4	56.1	78.5	63.7	60.8	83.7	68.11	8	38.00	11.33	58.60
NE18435	21	73.9	70.4	52.5	77.8	72.8	49.4	78.2	67.86	9	33.35	11.03	58.30
NE18625	23.3	67.1	66.1	58	82.5	80.5	50.4	70.3	67.84	10	35.00	10.53	58.45
NE18530	25.8	56.3	65.3	68.3	80.5	68.7	47.6	77.1	66.26	11	35.28	11.53	57.80
NE18544	20.4	72.5	66.5	46.2	75.9	70	51	81.6	66.24	12	33.43	9.67	45.70
Freeman	20.1	72.5	62	52.4	85.5	61.1	44.8	84	66.04	13	33.63	10.33	57.45
NE18455	24.3	68.4	64.2	59.2	72.8	59.5	53.9	83.6	65.94	14	34.20	11.77	58.35
NE18517	19.8	69.6	54.7	65.1	83.9	63.6	42.6	81.5	65.86	15	36.30	11.03	59.45
NE18445	20.3	62	57.3	59.8	63.9	96	36.3	85.6	65.84	16	34.15	10.83	56.25
NE18456	20.7	76.7	60.7	54.1	67.7	78.1	53.1	68.5	65.56	17	35.35	11.03	57.15
NE18562	14.7	62	58.1	61.8	71.9	62.7	56.3	84.7	65.36	18	34.33	11.33	59.10
NE18466	11.1	75.6	60.4	47.8	79	54.7	47.2	90.9	65.09	19	33.33	11.67	60.15
NE18472	19	71.3	62.1	49.6	80.2	78	35.5	78.9	65.09	19	34.75	9.77	47.35
NE18634	20.4	59.8	51.7	67.7	80.1	73.4	44.7	75.4	64.69	21	37.38	12.13	57.20
NE18527	21.3	72.4	53.8	52.6	76.1	52.9	56.3	88.1	64.60	22	34.70	11.60	60.00
NI15713-3	14.4	72.9	61.3	62.9	64.5	58.8	46.6	83.3	64.33	23	33.00	8.60	31.85
NE18463	22.2	65.7	65.7	51.3	83	58.6	51.8	74.1	64.31	24	35.63	11.83	59.00
NE18418	32.3	72.4	57.8	42.6	79	64.4	51.6	81.8	64.23	25	34.50	11.53	60.60
NE18644	22.7	66.4	66.2	58	68.3	59.6	54.5	75.7	64.10	26	36.23	12.37	63.85
NE18628	25.3	68	57.2	55.7	68.2	73.8	52.2	73	64.01	27	36.78	12.17	60.25
NE18595	28.6	69.1	67.1	48.8	74.7	60.2	42.6	84.6	63.87	28	35.45	11.30	57.80
NE18641	28.6	63.5	55	56.7	86.1	64	45.7	75	63.71	29	34.73	11.77	61.30
NE18430	23.6	75.8	58.9	39.1	68.7	80.2	44	78.7	63.63	30	33.85	11.80	59.85
NE18457	19	73.3	59.3	57.7	78.2	51.4	44.8	80.1	63.54	31	35.70	11.53	59.90
NE18514	17.7	57.1	48	57.5	85.1	64.2	54.5	77.8	63.46	32	35.50	10.97	56.95
NE18526	31.1	73.5	57.3	55.3	71.6	58.6	53.1	74.4	63.40	33	34.03	11.43	56.15
NE18577	18.4	60.1	56.8	55.9	77.1	59.9	52.1	81.6	63.36	34	36.23	11.90	59.15
NI14733-3	15.1	76.8	55.7	42	74.1	75.6	35.7	79.9	62.83	35	31.60	11.40	58.85
NE18622	18.3	63.4	47.4	54.5	84.1	65.9	48.7	74.1	62.59	36	34.98	12.40	60.55
NE18489	19.6	61.1	47.9	54.3	68.5	75.4	53.6	77.2	62.57	37	37.63	11.27	48.15
NE18624	13.9	56.9	49.3	54.5	84.7	66.9	42.1	82.9	62.47	38	35.48	11.80	58.00
NE18422	23.8	80.2	50.7	61.1	59.7	57.9	52.6	73.2	62.20	39	37.60	10.50	47.35
NI12702W-1	22.7	82.2	53.7	46.8	69.6	50.5	48.1	83.5	62.06	40	34.43	11.50	58.80
NE18448	20.6	63.6	58.6	51.3	74.2	58.3	48.5	79.7	62.03	41	34.53	11.27	58.20
NE18409	20.8	68.3	67.1	49.6	79.5	60.4	29.6	77.3	61.69	42	33.80	11.60	58.85
NW13493-1	28.3	73.6	58.9	43.4	75.7	64.8	42.8	70.8	61.43	43	32.33	11.17	58.00
NE18475	17.6	57.2	54.8	52.7	75.1	67.3	40.5	80.2	61.11	44	33.20	10.13	47.00
NE18540	14.9	69.8	58.2	51.7	66	59.3	48.2	74	61.03	45	35.33	11.77	59.40
NHH18654	17.2	67.5	63.3	48.4	81.5	53.6	38.5	74.3	61.01	46	32.68	11.27	60.50
NE18587	23.9	61.1	44.4	64.3	76.5	64.2	44.9	70.5	60.84	47	36.68	11.57	57.35
NE18480	22.4	74.4	55.4	44	68.1	52.2	48.7	82.7	60.79	48	36.95	9.53	44.60
NE18553	23.5	69.5	56	48.4	78.1	57.8	34.7	79.8	60.61	49	34.43	10.47	57.30
NE18479	19.3	62.4	46.7	54.7	70.4	72.7	40.7	76.5	60.59	50	33.90	11.67	59.50
NE18556	18.3	71.6	56.5	49.7	80.5	51.4	29.9	84	60.51	51	33.23	10.43	57.95
NW13493-3	29.3	70.9	52.7	42.9	76.5	68.2	36.9	73.9	60.29	52	33.93	9.93	44.35
Ruth	15.3	67.4	47.4	46.9	70.8	56.6	46.9	83.9	59.99	53	34.70	11.17	58.35
NE18403	18.5	70.2	59.2	33.9	71.3	69.5	44.4	68.6	59.59	54	31.90	9.20	41.45
NE18531	22.9	63.3	59.2	45.9	73.2	57.4	40.1	77.4	59.50	55	33.08	11.37	58.75
GOODSTREAK	20.6	61.4	41.9	60.3	64.2	61.5	55.4	71.5	59.46	56	39.83	11.80	57.65
NE18513	17	64.7	60.3	50.3	74.3	50.3	45.4	70.7	59.43	57	33.60	12.07	60.90
NE18427	14.4	63.5	50	53.1	73.2	57.6	34.6	76.8	58.40	58	36.43	11.63	58.30
NE18666	25.4	65.5	55.4	57.7	64.8	42.4	47.4	75.3	58.36	59	37.35	8.50	33.20
NE18515	17.9	65.4	55.6	46.1	64.4	50.7	49.3	69.6	57.30	60	36.43	11.37	59.20
GRAND MEAN	21.44	68.49	57.81	53.86	75.56	64.48	47.35	78.47					
CV	14.4	11.49	13.09	10.15	8.28	13.79	19.76	6.41					
Heritability	0.66	0.21	0.29	0.57	0.38	0.43	0.15	0.39					
LSD	5.01	12.78	12.29	11.07	15.21	17.82	18.73	10.07					

The data for 2018 are:

	Mead	Lincoln	C.Center	N. Platte	McCook	Grant	Alliance	St. Avg.	
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Rank
	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	
NewName	yb_m18	yb_ln18	yb_cc18	yb_np18	yb_mc18	yb_grd18	yb_al18		
NE17483	56.8	82.7	73	69.2	59.8	84.8	65.5	70.26	1
NE17545	56	72.1	56	66.6	70.1	90.3	72.2	69.04	2
NE17443	48.9	73	68.4	64.9	71	85.7	64.5	68.06	3
NE17578	52.2	81.8	68.6	63	66.5	79.6	60.9	67.51	4
NE17441	60.7	79	66.3	60.6	59.6	74.5	70.2	67.27	5
NE17563	52.6	76.9	70.1	58.3	61.4	79.2	69.1	66.80	6
NE17415	60	76.7	60.8	59	62.8	77.8	69.3	66.63	7
NE17627	58.2	81.9	54.6	60.6	67.6	78.2	64.8	66.56	8
NE17506	57.9	77.5	67.1	61.1	57.4	72.6	68.1	65.96	9
NE17528	54.9	82.9	67.3	60.1	66.9	67.9	61.4	65.91	10
NHH17612	50.4	71.1	64.8	71.6	62.7	75.7	64.7	65.86	11
Ruth	49.3	73.3	54.2	69.5	62.9	79.1	71.3	65.66	12
NE17433	44.2	72.1	56.9	59.7	69.2	82.6	74	65.53	13
NE17609	48.6	74.2	61.7	55.5	69.5	76.9	68	64.91	14
NE17608	56.3	70.8	61.1	59.2	65.5	76	64.2	64.73	15
NE17524	52.2	78.6	59.1	54.2	68.8	76.4	61.4	64.39	16
NE17486	52.4	72.3	62.5	70.1	53.6	74.6	59.6	63.59	17
NE17616	56.4	75.3	65	55.8	56.6	73.4	62.6	63.59	17
NHH17503	55.3	76.1	70.7	53.2	55.2	71.2	62	63.39	19
GOODSTREAK	58.2	69.1	68.5	48.4	61.1	75.4	62.9	63.37	20
NE17452	45	73.4	66.1	56	63.7	78.8	60.4	63.34	21
NE17590	51.7	62.1	64.6	58.8	61.5	78.9	63.2	62.97	22
NE17470	55.4	64.2	60.6	56.7	63.1	74.1	64.8	62.70	23
NHH17450	46.1	67.7	61.7	58.8	65.2	78.5	60.2	62.60	24
NE17564	55.7	68.9	57.5	47.4	59.9	83.4	64.8	62.51	25
NE17512	52.2	77.1	58	41.3	60.6	80.4	66.5	62.30	26
NE17439	54.7	66.8	57.7	55.8	61.2	72.7	66.9	62.26	27
NE17481	53.2	68.4	63.9	60.9	59.4	75.6	53.9	62.19	28
NE17639	54.2	70.1	54.1	58.6	66.3	70	61.1	62.06	29
NE17614	48.7	73.3	62	50.6	58.7	75.6	65	61.99	30
NE17515	51.8	66.7	57.1	62.7	59.2	71.4	64.5	61.91	31
NE17417	56.2	64	55.1	61.6	60.1	71.5	64.8	61.90	32
Freeman	46.8	58.3	55.8	61.4	61.8	80.9	67.1	61.73	33
NE17603	56.8	74.5	65.4	44.4	56.3	68	65.5	61.56	34
NE17408	49.4	50.1	61.5	68.2	59.1	80.3	61.4	61.43	35
NE17661	52.1	72	56.3	55.4	56.9	71.3	65.4	61.34	36
NE17480	46.7	61.7	57.9	55.5	60.5	81.5	65.5	61.33	37
NE17576	44.6	68.3	60.2	67.3	55.2	74.1	59.4	61.30	38
NE17479	46.1	62	62.4	62.1	56.6	74.6	64.3	61.16	39
NE17596	45.6	59.8	62.1	66.5	61.7	69.1	63	61.11	40
NE17602	53.1	63.4	47.2	67.1	55.3	76.1	65.2	61.06	41
NE17582	49.4	70	55.8	51.2	52.1	81.1	66.1	60.81	42
NE17606	47.5	60.9	51	59.5	64.3	80.3	59.4	60.41	43
NE17496	51.1	55.5	53.8	64.2	58.4	76.9	62.2	60.30	44
NE17648	54.6	71.3	49.7	67.2	53.3	59.3	66.4	60.26	45
NE17434	52.1	62	53.1	60.8	56.1	72.2	65.5	60.26	46
NE17601	49.2	62.7	56.4	48.4	62.2	76.5	61.1	59.50	47
NE17547	43.9	53	59.5	66.7	60.6	73.2	58.5	59.34	48
NE17402	51.8	69.5	52.1	55.1	46.9	74.3	64.8	59.21	49
NHH17557	49.8	57.2	61.4	68	58	64.4	55.1	59.13	50
NE17550	47.5	61.4	52.4	59.1	61.1	64.4	66.5	58.91	51
NE17539	53.6	54.1	56.3	63.3	40.5	71	69.1	58.27	52
NE17427	48.2	63	48.5	57.5	61.6	72.7	55.5	58.14	53
NE17435	55.9	63.2	56.6	42.9	54	69.5	64.5	58.09	54
NE17593	52.8	65.6	49.1	57.7	51.1	68.8	59.8	57.84	55
NE17472	48.9	45.1	47.5	63.4	55.7	71.9	63.1	56.51	56
NE17538	49.6	48.3	43.1	51.5	55.6	69.4	66.8	54.90	57
NE17426	48.1	45.5	56.7	52.9	47.4	73.6	57.4	54.51	58
NE17444	39.6	53.8	46.2	53.3	50.3	69.4	67.5	54.30	59
NE17409	37.4	57.6	46.9	55.1	58.9	54.7	60.9	53.07	60
EAN	51.31	67.15	58.67	58.92	59.64	74.71	63.99		
	6.03	7.62	10.67	10.94	10.92	14.79	8.5		
	7.24	6.99	11.19	9.15	7.53	9.77	8.18		

The data for 2017 are:

Name	Mead Yield Bu/a	Lincoln Yield Bu/a	ClayCent. Yield Bu/a	N.Platte Yield Bu/a	McCook Yield Bu/a	Grant Yield Bu/a	Sidney Yield Bu/a	Alliance Yield Bu/a	Average Yield Bu/a	Rank
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**	

6. **Regional Nurseries** (data courtesy of S. Masterson)

In 2019, 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. 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. The lowest yielding line was developed as a forage wheat. What was surprising is that two lines (NE16562 and NI1740) performed well across the region which is very rare as we are a northern (late) site for breeding. The last line with performance well across the region was Robidoux.

The data for the 2019 SRPN are:

	SRPN Overall		Clay Center, NE		Lincoln, NE		North Platte, NE		Sidney, NE		Alliance, NE	
Line	**Mean**	**Rank**	**Mean**	**Rank**	**mean**	**rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**
Kharkof	2817	49	1977	49	2726	49	3020	44	3265	48	3714	48
Scout66	3324	47	3082	47	2777	48	2573	48	3598	44	4104	47
TAM-107	3790	46	4161	26	3623	40	2984	45	3107	49	4730	33
Jagalene	4026	45	3336	45	3540	42	3414	36	4035	33	4313	43
NEDI4-4006	4997	2	4495	9	4069	31	3921	18	5266	4	5748	2
NEDI4-4030	4798	15	4725	5	3777	36	4326	7	4852	14	5033	16
NEDI4-4066	5090	1	4474	10	5593	6	3840	23	5276	3	4985	18
NEDI4-4802	4804	13	4595	7	5779	1	4134	12	3944	39	4239	46
KS14HW106-6-6	4585	31	4008	34	4669	16	3708	28	3820	41	4905	24
KS15H116-6-1	4848	8	4194	23	3685	38	4176	11	4744	17	5275	8
KS15H161-1-4	4450	36	4196	21	3392	44	2892	46	3779	43	4918	23
NHH144913-3	**4769**	**16**	**4044**	**33**	**4725**	**15**	**5059**	**1**	**5047**	**9**	**4959**	**21**
NE15624	**4464**	**35**	**4055**	**32**	**5075**	**9**	**3638**	**30**	**4328**	**26**	**5221**	**9**
NE16562	**4889**	**6**	**4927**	**4**	**5775**	**2**	**3615**	**33**	**4869**	**13**	**4824**	**31**
NI17410	**4950**	**4**	**4358**	**13**	**5743**	**3**	**2730**	**47**	**5185**	**5**	**5115**	**12**
CO13D0787	4602	28	3983	35	4046	32	3853	21	4210	28	4728	35
CO15D098R	4844	10	4118	28	4078	30	4006	15	5158	8	5947	1
CO15SFD107	4076	44	3544	44	3376	46	3528	35	3988	36	5299	7
CO13D1479	4364	42	3827	38	3210	47	4867	2	4832	15	4853	29
LCH13DH-46-1524	4636	24	3741	41	3640	39	3318	39	4129	31	4887	25
LCH13DH-47-1675	4414	38	4259	18	3544	41	3759	25	5185	6	5539	4
DH11HRW55-4	4866	7	4196	22	4566	18	3268	42	5316	2	4878	26
LCH15ACC-8-21	4635	25	4315	15	4320	24	3627	32	4802	16	4730	34
TX14A001249	4604	27	5194	2	4286	26	4611	4	3971	37	4992	17
TX14A001035	4811	12	4178	24	4499	20	3963	17	4882	12	4923	22
TX14M7061	4404	40	4165	25	4013	33	3224	43	4011	35	4829	30
TX15A001482	4435	37	3802	39	3392	45	4210	9	4085	32	4667	38
TX14V70214	4801	14	5290	1	4990	10	4472	5	4704	18	4620	39
TX09V7446-16AZ40	4412	39	4073	30	3844	35	3995	16	4011	34	4609	40
TX15M8024	4601	29	4367	12	3721	37	3329	38	5178	7	4459	41
TX15M8023	4632	26	4250	20	4084	29	3732	26	3894	40	5183	10
TX15M8456	4555	33	3869	36	4230	27	3712	27	4452	20	5124	11
18CP010073	4975	3	3647	42	4591	17	4779	3	4136	30	5313	6
18CP010085	4391	41	3786	40	4898	13	1867	49	3366	47	4741	32
18CP010155	4703	19	4259	19	4306	25	3865	20	4977	10	5080	14
18CP010129	4845	9	4326	14	4849	14	4194	10	4445	21	5463	5
KS080093K-18	4755	17	4586	8	4391	22	4385	6	5531	1	4961	20
KS090049K-8	4832	11	5093	3	5692	4	4125	13	4428	23	5104	13
KS090387K-20	4754	18	4315	16	4990	11	4042	14	4328	27	5035	15
KS12DH0156-88	4648	22	4149	27	4185	28	3844	22	3816	42	4268	45
NF97117	3236	48	2719	48	3479	43	3313	40	3588	46	3672	49
OK14P212	4643	23	3150	46	5665	5	3387	37	4381	24	4279	44
OK16D101073	4524	34	4315	17	4456	21	3306	41	4163	29	4456	42
OK16D101089	4600	30	4073	31	4360	23	3591	34	3954	38	4974	19
OK14P736W	4247	43	3616	43	3907	34	3768	24	3598	45	4687	37
OK16729W	4942	5	4690	6	5275	7	3636	31	4963	11	4871	28
NE14691	4572	32	3858	37	5252	8	3914	19	4439	22	4723	36
OK1059018-129332-5	4693	20	4400	11	4900	12	4280	8	4354	25	4878	27
Tx04CS231-12	4673	21	4075	29	4557	19	3699	29	4549	19	5584	3
Mean	4538		4099		4338		3755		4387		4866	
l.s.d. (alpha = 0.05)	127.9		810.1		1006.5		937.1		749.4		678.1	
MSE	169830		249805		385627		311564		138910		175060	
n	81		3		3		3		3		3	
CV	9.1		12.2		14.3		14.9		8.5		8.6	

In the NRPN, the lines performed quite differently across environments showing how different the environments were this year. The success of some of the North Dakota lines indicated later maturity lines were favored in this nursery in this year.

The data for the 2019 NRPN are:

	Overall NRPN		Lincoln, NE		North Platte, NE		Sidney, NE[*1]		Alliance, NE	
Line	mean	rank	mean	rank	mean	rank	mean	rank	mean	rank
Kharkof	3332	48	2726	43	3020	46	3265	48	3714	48
Overland	4555	27	4569	14	3551	40	4768	26	4831	34
Wesley	4334	35	3028	42	4456	16	4553	29	5203	11
Jagalene	4291	39	3540	40	3414	42	4035	43	4313	45
Jerry	4384	34	3683	34	4134	27	4324	38	4667	40
NEDI4-4006	4752	12	4069	26	3921	33	5266	9	5748	1
NEDI4-4030	4718	16	3777	31	4326	20	4852	24	5033	23
NEDI4-4039	4865	5	4111	24	5071	7	5061	14	5111	19
MODI4-4919	4157	43	2190	45	3835	36	5168	13	4950	29
NE14691	**4416**	**31**	**5252**	**6**	**3699**	**38**	**4439**	**32**	**4723**	**38**
NE14696	**4721**	**15**	**4501**	**15**	**3654**	**39**	**4412**	**33**	**5201**	**12**
NI14729	**4635**	**21**	**4416**	**17**	**4304**	**22**	**4630**	**27**	**5387**	**6**
NE15410	**4409**	**32**	**4109**	**25**	**4210**	**25**	**4139**	**42**	**4844**	**33**
NW15404	**4302**	**36**	**4891**	**9**	**3006**	**47**	**3793**	**44**	**5436**	**5**
NE15624	**4641**	**20**	**5775**	**1**	**3831**	**37**	**4869**	**21**	**4824**	**35**
NW15443	**4749**	**14**	**4817**	**11**	**3912**	**34**	**4358**	**37**	**4994**	**26**
NE16562	**4775**	**11**	**5743**	**2**	**3297**	**44**	**5185**	**11**	**5115**	**18**
NE16593	**4595**	**25**	**4317**	**20**	**4322**	**21**	**4886**	**20**	**5109**	**20**
ERYTHRO2420-2010	4289	40	4743	13	4062	29	3363	46	5028	24
DH12HRW44-144	4626	22	4385	18	4414	18	5915	2	4755	36
LCH12DH-21-50	4800	8	3551	39	5326	3	4973	17	5189	13
ERYTHRO1939-2012	4295	37	4212	21	3170	45	5178	12	5299	9
DH11HRW52-5	4791	10	4894	8	4728	11	5363	5	5611	3
18CP010076	4292	38	5441	4	3342	43	4163	41	4743	37
18CP010083	4482	29	4170	23	4351	19	4926	19	5122	17
18CP010156	4707	17	4024	28	3950	32	5360	6	4690	39
18CP010160	4678	18	5665	3	4093	28	4368	36	5207	10
18CP010094	4017	46	3300	41	4057	30	4469	31	5012	25
17NORD-90	4540	28	3652	35	4602	12	4869	22	4414	42
17NORD-91	4407	33	4472	16	4232	23	4475	30	3905	47
17NORD-92	4263	41	3598	36	5082	5	4280	40	4315	44
17NORD-94	4749	13	4914	7	5391	2	4388	35	4582	41
17NORD-96	5061	1	4039	27	5555	1	6520	1	5333	8
MT1642	3919	47	1836	48	3849	35	4412	34	4916	30
MT1683	4239	42	1883	47	3436	41	3608	45	4963	27
SD12DHA01373	4677	19	4181	22	4575	13	5770	3	5136	15
SD12DHA03282	4794	9	3580	38	4911	9	5595	4	5364	7
SD13062-2	4833	7	3992	29	4829	10	5333	7	4900	32
SD13099-8	4879	4	4775	12	4443	17	4963	18	4961	28
SD13DHA02346	4601	23	3735	32	4981	8	4866	23	5131	16
SD13DHA02489	4588	26	3580	37	4530	14	4997	16	5075	21
SD14113-3	5015	2	4833	10	5151	4	5198	10	5494	4
SD14115-5	4987	3	5387	5	4515	15	5000	15	5741	2
SD15103-6	4596	24	4378	19	4044	31	4566	28	5057	22
SD15205-1	4861	6	3867	30	5075	6	4802	25	5142	14
AAC Wildfire	4427	30	1903	46	4156	26	5306	8	4329	43
AAC Goldrush	4125	45	2490	44	4228	24	4301	39	4006	46
Matterhorn	4154	44	3721	33	2923	48	3285	47	4909	31
SAS Mean	4527		4049		4208		4721		4949	
l.s.d. (alpha = 0.05)	287839		902.3		833.0		905.6		606.3	
MSE	213		303262		263988		202636		139863	
n	49		3		3		2		3	
CV	11.9		13.6		12.2		9.5		7.6	

7. Multiple-Location Observation Nursery

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. The table below gives the grain yields for all of the harvested locations, the line average, and the rank of the top 15 highest yielding lines. In this nursery, we continued to use marker-assisted selection for line advancement. Currently our dense genome-wide SNP markers allow us to predict the presence of more than 50 traits (growth and development genes, major disease and insect resistance genes, and end-use quality genes) exploiting the linkage disequilibrium with previously known markers for these traits.. For the sixth year, we used genotyping by sequencing (GBS) to genotype the breeding lines and genomic selection for grain yield.. The top fifteen lines out of 270 experimental lines are below. As can be seen some of the selected lines had low genetic estimated breeding values (GEBVs) because they seem to do particularly well in some section of the state and the GEBVs are based upon the state-wide averages and performance over the years (starting in 2012).. Historically, the lines that eventually become varieties are those that do well phenotypically (e.g. high grain yield) and also have higher GEBVs (priority group 1). We believe the excellent phenotypic values in a given year prove the line can do well in one year and the excellent GEBVs document that it can do well on average for the other years (the basis for obtaining the estimated breeding values is multiyear trials). Some lines with less than desirable stem rust values (SR, e.g. > 2+) are kept because the stem rust tests are seedling tests and some lines may have adult plant resistance.

				Mead	Lincoln	C.Center	N.Platte	McCook	Grant	Sidney	Alliance	KANSAS	NE_All_Ave	RANK_NE_	GEBV_yldbua	PriorityGroup_
				Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield			GEBV+BLUP_yldbua
				bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a			
newname	SR	SR	pedigree	Mead	Lincoln	C.Center	N.Platte	McCook	Grant	Sidney	Alliance	KANSAS	NE_All_Ave	RANK_NE_	GEBV_yldbua	PriorityGroup_GEBV+
NE19430	2 3+	2	KS020319-7-2/NH11563//NE06545	23.14	73.23	56.63	62.44	76.60	92.74	68.78	85.87	53.82	67.43	3	**1.52**	**1**
NE19590	1	2 3	NE10418/NE06545	31.04	73.41	68.34	55.63	79.66	76.23	68.09	86.15	59.16	67.32	1	**-0.15**	**4**
NE19415	4 1	3	MT08172/NI06736W	25.49	73.82	64.66	60.90	88.27	75.05	69.59	79.44	53.91	67.15	4	**-2.06**	**4**
NHH19668	2 1	3-	OK09915C/NH11565	20.31	72.77	71.67	67.54	80.48	83.55	61.82	77.83	49.75	67.00	6	**1.53**	**1**
NE19471	2 4	2	KS031009K-4/NE05496	37.16	74.40	57.01	58.88	80.20	72.26	71.10	84.32	48.09	66.92	11	**0.77**	**2.2**
NE19451	1	1 2	NE13447V/N11MD2129	29.13	71.68	64.82	60.56	84.99	69.93	72.26	79.09	60.58	66.56	2	**2.27**	**1**
NE19544	2	1 2	TX07A001505/WB-Hitch	31.90	71.11	55.98	65.37	75.78	79.98	70.80	78.45	53.16	66.17	8	**2.33**	**1**
NE19570	1	2	KS020319-7-2/NE11455//NE11455	29.64	73.28	68.27	55.23	81.47	76.91	69.48	73.84	52.65	66.02	15	**0.46**	**2.2**
NE19431	2 1	4 1	Thunder CL/NE08452//Thunder CL/3/NH1	31.40	74.52	59.06	59.32	90.34	66.88	70.13	76.41	54.48	66.01	14	**1.27**	**2.2**
NE19416	2 3	4	NI04420/SD09192	24.75	74.02	59.78	61.76	78.66	78.23	76.05	73.39	56.22	65.83	13	**-1.52**	**4**
NE19619	2-	1 0	TRCH/SRTU//KACHU/7/VEE8//JUP/BJY/3	28.64	71.47	69.25	55.83	82.24	68.95	70.56	79.29	58.18	65.78	7	**-0.55**	**4**
NE19455	1	;	NE09521/NE11656	26.50	72.66	67.02	56.47	82.32	64.20	71.17	85.75	54.04	65.76	16	**0.89**	**2.2**
NE19638	4 1	0 1	SD08200/NE06545	22.49	73.80	59.48	59.20	83.99	70.13	74.17	81.66	58.85	65.62	10	**1.84**	**1**
NE19528	3 2 1	1	NE10418/NE06545	25.31	72.16	60.34	57.62	83.34	77.03	70.02	78.70	62.50	65.57	5	**-0.33**	**4**
NE19586	4	1	LCH08-80/NE06545	25.86	73.52	64.80	63.88	82.90	57.46	66.37	88.99	58.76	65.47	12	**2.02**	**1**

The top 15 lines for 2018 are: Of the top 15 lines (5.5% of the total number of lines), seven were in the top 15 lines in the TRP19 (~50% of the elite lines as one of the top 15 lines in the TRP19 was a check variety).

entry	pedigree	SR score	Mead_yld_B	Lincoln_yld_	ClayCenter_y	NorthPlatte_	McCook_yld_	Grant_yld_B	Sidney_yld_B	Alliance_yld_	Kansas_yld_	NE_All_Ave	GEBV_yldbua
NE18544	**NI09709/NI04421**	2+2X	**57.73**	**77.39**	**82.12**	**68.83**	**68.50**	**78.87**	**78.18**	**72.60**	**42.06**	**73.03**	**-0.34**
NE18412	**NW11590/T 154//N**	;	**62.68**	**78.82**	**81.30**	**72.10**	**69.03**	**77.73**	**74.65**	**64.58**	**43.49**	**72.61**	**-0.01**
NE18573	TX07A001118/Freen	2+;	62.61	78.99	87.54	60.69	66.69	78.73	73.55	65.20	42.20	71.75	**1.29**
NE18422	KS11U5899R2/NW1	;1+	58.99	72.70	78.53	67.67	66.90	77.27	82.30	68.99	42.61	71.67	**1.45**
NE18509	KS08HW35-1/Camel	22-N	62.72	77.61	60.22	75.89	70.16	76.72	76.31	71.65	44.55	71.41	**1.51**
NE18583	NE09517/SD06158	33+	59.13	78.38	73.69	68.84	70.09	75.58	76.59	65.08	42.84	70.92	**1.90**
NE18466	NE09521/Freeman	;/1-	60.97	72.60	68.70	49.27	69.93	78.17	84.84	79.01	44.34	70.44	**0.19**
NE18514	CO050337-2/SD050	2-;	63.54	72.77	63.89	74.01	64.46	77.38	76.54	67.33	41.56	69.99	**0.84**
NE18624	NW11511/Snowmas	1+	49.44	76.29	70.81	63.28	68.55	77.93	84.36	68.79	42.66	69.93	**0.27**
NE18553	U5935-2-3/NI07703	22+	52.56	75.42	75.33	67.32	66.36	77.12	79.21	64.95	42.31	69.78	**-0.15**
NE18640	NW03666/ms(t)-77(	1;	62.03	74.04	74.87	62.54	71.59	75.81	72.10	63.36	40.66	69.54	**2.50**
NE18435	TX07A001505/NE05	2-;	57.46	76.86	73.93	55.34	69.83	77.28	70.77	74.49	43.68	69.50	**-2.16**
NE18455	TX07A001505/NE06	;	58.11	71.49	62.99	74.79	63.87	76.84	83.05	64.57	42.77	69.46	**0.81**
NE18418	U5942-10-1/NW075	;/2-	62.75	70.48	67.93	57.32	67.74	78.43	77.97	71.26	42.19	69.23	**2.51**
NE18595	NW10487/NW0753	1;	63.41	82.39	67.36	50.74	65.33	76.70	76.52	71.32	42.62	69.22	**1.50**

The data for 2017 are: Of these 10 highest yield lines, 3 were in the top 16 lines in the 2018 TRP nursery and 2 were advanced to the NIN19. However, none were advanced to the NIN20. Historically, these three lines would be the most likely to be released. Some of the elite lines were selections out of NW13493, but not superior to NW13493, hence not advanced.

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_B	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 summary of the early generation nurseries is:

2019	Planted	Selected
WF2	1192	1000
Imi-WF2	70	62
WF3	1016	450
Imi-WF3	92	48
Headrows	47760	1533
Imi-Headrows	4800	290
Preliminary Observation Plot	1468	250
Imi Preliminary Obs. Plots	136	20

These numbers are fairly normal for the nurseries. In retrospect, fewer WF3s should be selected with possibly more lines selected within a population.

9. Winter Triticale Nursery

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 forage based, cover crop, or 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 has potential for human consumption. The forage can be used as forage, cellulosic ethanol feed stocks, or as a ground cover, an emerging market. In the cover crop market it competes with rye, wheat, and barley. Triticale has excellent biomass (greater than wheat and barley) and does not have the volunteer concerns associated with rye. In 2015, it appeared that NE422T had good forage potential for the southern Great Plains, but like most forage triticale lines, its grain yield was very low and the seed was very poor quality. 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. In 2019, our elite triticale trial was harvested at Lincoln and Sidney. Mead (grain and forage) was lost to winterkilling and flooding.

The data for 2019 are:

NAME	Lincoln Yield lbs/a	Sidney Yield lbs/a	Average Yield lbs/a	Rank	Heading Date D after 1/1	Average Height (in)	Lodging	LR
NT05421	3152	4452	3802	22	146.7	54.3	6.4	3
NT07403	4065	4019	4042	16	143.16	45.5	2.8	4
NT09423	3203	4845	4024	17	146.89	49.5	3.2	6
NT12403	4213	4698	4456	7	144.32	51.3	1.5	3
NT12404-1	4794	4752	4773	2	145.15	49.7	1.5	3
NT13416	3916	4554	4235	10	145.54	54.5	3.7	3
NT14407	4395	5078	4737	4	144.21	52.7	2.8	5
NT14433	4456	3649	4053	15	146.56	59.7	7	1
NT15406	5394	4128	4761	3	143.69	48.6	2	3
NT15428	4247	4121	4184	11	145.21	48.0	3.2	2
NT15440	3402	4443	3923	19	148.35	54.5	7.8	0
NT16402	4663	4002	4333	8	143.75	47.0	1.7	2
NT16404	2477	3394	2936	29	147.88	58.9	6.1	3
NT441	1752	4349	3051	28	149.38	61.9	3.8	8
OVERLAND	2969	4034	3502	26	147.09	41.6	4.4	8
NT17407	3939	3735	3837	21	145.12	48.5	2.5	2
NT17410	4012	3993	4003	18	147.36	51.1	3	2
NT17422	4265	4370	4318	9	145.68	51.6	4.1	2
NT17441	3150	5007	4079	13	149.77	57.3	6.3	2
NT17442	4137	4229	4183	12	147.87	57.6	6.9	2
NE03T416-1	3966	5402	4684	5	146.28	46.8	2.4	1
NE03T416-3	3802	5966	4884	1	147.73	46.3	2.7	2
NT12403-1	3801	4326	4064	14	143.92	48.2	1.3	2
NT14433-3	3256	3777	3517	24	146.75	59.5	6.5	1
NT18410	4675	4279	4477	6	145.58	49.4	5.1	2
NT18417	3739	3535	3637	23	145.09	54.3	5.7	3
NT18424	3502	4215	3859	20	147.63	56.4	4.3	3
NT18428	3180	2451	2816	30	147.62	53.3	6.1	1
NT18430	3513	3495	3504	25	148.31	56.7	3.1	2
NT18432	2586	4043	3315	27	147.08	57.5	7.5	1
GRAND MEAN	**3754**	**4245**	**3999**		**146.32**		4.18	2.78
LSD	1001.97	1250.53	1126.25		2.06		2.61	2.43
CV	16.21	17.89	17.05		0.86		37.87	53.05

Note the grain yield is reported as lbs/a because a triticale bushel is 48 lbs (just like barley). The names highlighted in yellow have been released. Using lbs/a allows direct comparisons to wheat. Overland is a representative wheat variety. As can be seen, Overland yielded 2969 lbs/a (49.5 bu/a) at Lincoln and 4034 lbs/a (67.2 bu/a) at Sidney and was relatively low yielding compared to triticale. Triticale is taller than wheat and may shade or otherwise compete aggressively against a semidwarf wheat. The mean performance of Overland at Lincoln (with no fungicide spray) was 66.6 bu/a and at Sidney was 57.4 bu/a. By comparison the best triticale NE03T416-3 had a grain yield of 3802 lbs/a at Lincoln and 5966 lbs/a at Sidney and averaged 39% greater grain yield than Overland.

The data for 2018 are: Sidney was lost to storms before harvest.

	Lincoln				Mead			Average		Mead Forage	
	Yield	Height	Flowering date	Test Wt	Yield	Height	Test Wt	Yield	Height	Dry Matter	Dry Biomass
Variety	lbs/a	in	D after Jan.1	lbs/a	lbs/a	in	lbs/a	lbs/a	in	%	lbs/a
NT16402	3692	45.9	143.4	48.7	3692	38.2	47.5	3692	42.1	0.28	3022
NT16404	3807	44.8	146.0	49.4	3207	46.3	51.1	3507	45.6	0.26	3047
NT16406	3664	46.7	146.6	48.0	3344	42.7	47.6	3504	44.7	0.25	2919
NT12404-1	4207	41.8	144.3	50.0	3794	39.3	48.3	4001	40.6	0.28	3007
NT12425-1	3424	35.3	143.4	50.1	3280	33.3	47.6	3352	34.3	0.26	2529
NT05421	3766	45.5	146.1	47.1	3418	46.2	47.7	3592	45.9	0.24	2891
NT06427	3764	43.2	144.9	45.3	3390	38.7	45.3	3577	41.0	0.25	2780
NT07403	4274	42.0	143.0	50.0	3739	40.7	49.4	4007	41.4	0.29	2975
NT09423	3768	42.1	146.2	49.1	3293	41.7	48.9	3531	41.9	0.24	2622
NT11428	4085	48.7	146.1	49.1	3534	45.7	49.6	3810	47.2	0.25	2771
NT12403	4409	44.9	144.3	48.8	3760	36.0	47.9	4085	40.5	0.27	2938
OVERLAND	3520	33.9	146.5	57.9	3222	32.3	58.3	3371	33.1	0.25	2525
NT13416	3652	45.0	144.5	48.8	3477	44.7	49.6	3565	44.9	0.28	3035
NT14407	3910	44.4	144.7	49.5	3869	43.0	49.6	3890	43.7	0.27	2964
NT14433	3269	46.1	145.8	50.6	3346	51.3	50.9	3308	48.7	0.27	3311
NT15406	3785	42.5	143.9	52.1	3370	41.7	50.7	3578	42.1	0.30	2947
NT15428	3886	43.1	144.4	48.4	3586	39.0	47.4	3736	41.1	0.27	2842
NT15440	3642	45.1	146.5	47.1	3342	45.0	47.7	3492	45.1	0.27	2893
NT441	3584	46.8	149.2	49.1	2998	46.3	49.5	3291	46.6	0.22	2871
NT13443	3220	52.7	147.2	49.1	3390	47.0	48.8	3305	49.9	0.25	2772
NT17441	4694	49.5	147.1	49.9	3924	49.7	49.8	4309	49.6	0.23	2798
NT17442	4196	48.0	148.9	50.4	3764	45.3	50.5	3980	46.7	0.22	2940
NT17430	3549	42.0	145.5	49.4	3528	36.7	49.2	3539	39.4	0.28	2693
NT17422	3943	44.5	145.0	47.0	3563	42.3	47.0	3753	43.4	0.27	2999
NT17406	3641	43.6	144.9	49.6	3321	43.0	50.3	3481	43.3	0.25	2716
NT17402	3170	40.9	143.8	48.1	3203	40.0	48.4	3187	40.5	0.26	2493
NT17407	4029	46.0	144.7	50.7	3421	45.7	50.9	3725	45.9	0.28	2991
NT17410	4409	43.0	144.3	46.7	3659	41.2	45.4	4034	42.1	0.26	2969
NT17403	3806	40.3	146.6	43.5	3550	38.2	44.7	3678	39.3	0.24	2645
NT17420	3751	45.9	145.1	49.8	3684	43.0	50.0	3718	44.5	0.28	2786
GRAND MEAN	**3814.6**	**44.1**	**145.4**	49.1	**3489.0**	**42.2**	49.0	**3651.8**	**43.1**	**0.3**	**2856.2**
LSD	540.2	4.6	0.88	0.6	377.2	4.6	0.9			0.02	306.5
CV	8.6	6.4	0.37	0.8	6.6	6.7	1.1			6.1	7.6

The grain yield data for 2017 are below. Note no forage data was collected in 2017 due to equipment breakdowns and a problem with planting.

	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				

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 as our resources allow.

The western forage trial was lost in 2019.

The 2018 Forage data from western NE (thanks to Dr. Dipak Santra) are:

Name	yldkgha
NT07403	8713
NT09423	8880
NT13443	9943
NT441	9628
NT13416	8678
NT05421	10657
NT16404	11207
NT16402	7825
NT12425-1	8163
NT15406	7124
KWS Progas	9619
KWS Propower	9526
GRAND MEAN	**9163.48**
LSD	**2648.04**
CV	**20.09**

The KWS lines are hybrid rye lines, so it was interesting to compare them to winter triticale which are pure lines. The 2017 western triticale forage trial was lost due to weather.

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 three-year (2017-2019) grain-yield data summary for locations where we were able to harvest trials is presented below. Again, the lines highlighted in yellow have been released. The line which may have the greatest potential for the next release is NT14433 which has excellent forage yield and better grain yield (18% better) than NT441. Hence it should be an excellent forage line with better seed production for seed producers.

Name	Grain Yield (lbs/a)	Grain Yield (lbs/a)	Grain Yield (lbs/a)	**State Avg Yield lbs/a**	**State Avg. Hdate (d after**	**State Avg. Height (in)**	Forage yldlbsa lbs/a	Forage dmpercent %
NT05421	3603	3398	3668	3570	144.0	51.6	2891	0.24
NT07403	3682	3976	3798	3882	140.0	44.6	2975	0.29
NT09423	3178	3109	4126	3499	144.4	46.8	2622	0.24
NT12403	4011	4168	4064	4133	141.6	47.4	2938	0.27
NT12404-1	4206	4644	4106	4370	141.9	46.5	3007	0.28
NT13416	3714	3949	4134	3927	142.5	51.0	3035	0.28
NT14407	3731	4124	4283	4114	141.4	49.4	2964	0.27
NT14433	3065	3515	3296	3403	143.6	56.6	3311	0.27
NT15406	3898	4616	4024	4226	140.5	46.4	2947	0.3
NT15428	3725	3931	3994	3905	142.0	46.8	2842	0.27
NT15440	3660	3606	3878	3701	144.9	51.3	2893	0.27
NT16402	4046	4557	4026	4204	140.4	45.6	3022	0.28
NT16404	3406	2892	3421	3197	144.0	54.9	3047	0.26
NT441	3104	2223	3408	2892	147.7	56.6	2871	0.22
OVERLAN	3131	2864	3442	3179	144.9	38.7	2525	0.25

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. <u>Collaborative Research on Wheat Diseases</u>

Dr. Stephen Wegulo, Department of Plant Pathology, and his staff continue to inoculate our experimental lines with wheat stem and leaf rust and Fusarium head blight (FHB, research funded by the U.S. Wheat and Barley Scab Initiative). We continue to improve the greenhouse tests for stem rust. With the advent of the new race of stem rust, Ug99 (which can overcome virtually all 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. As the new race is in Africa and now west Asia, we have continued our testing in Kenya as part of a USDA-ARS sponsored program and greatly expanded a program in Egypt which is capable of screening lines for both stem and stripe rust resistance. Remarkably, despite the very mild winter in Egypt, our wheat, barely, and triticale lines vernalize and head there.

Work continues on introgressing the resistance for wheat streak mosaic virus (WSMV) from *Agropyron* (*Wsm1*), but there appears to be a significant reduction in yield with the gene which may preclude its widespread use, so we are moving to *Wsm2* which is now widely used. It seems to have less effect on agronomic performance, but also may not be as effective in Nebraska as *Wsm1*. We are also introgressing a smaller chromosome segment containing *Wsm1*, which seems to have less detrimental effects on grain yield as does the original segment for *Wsm1*. Finally, we are beginning to work on curl mite resistance (the vector for WSMV) which also reduces the prevalence of WSMV in growers' fields. Thanks go to Dr. Gary Hein, entomologist, who is testing them in the field. With the continued spread of wheat soilborne mosaic virus in 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 our recent lines have this beneficial trait.

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

The best way to avoid the effects of scab (syn. Fusarium head blight, FHB) is by breeding resistant lines that in severe disease years respond well to fungicide treatments. Overland still has the best native resistance, but our newly released LCS Valiant has good FHB tolerance, as does the advanced experimental line, NW13493. In previous research, we found *Fhb1*, a major gene for FHB 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 has generated a number of advanced backcross lines using some of the best material in our program. For example, LCS Valiant which has good native resistance to FHB and excellent grain yield is one of the recurrent parent lines into which *Fhb1* is being backcrossed. She continues to work on using genomic selection for enhanced 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.

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

We are building a $F_{7;8}$ population of Wesley x Panhandle by single seed decent as an additional more homogeneous population of lines. This population will be widely shared for additional studies.

13. Hybrid Wheat: V. Belamkar, N. Garst, H. Stoll, N. Miller, E. Karahan, S. Blecha, P.S. Baenziger (University of Nebraska), A. Ibrahim (Texas A&M University), J. Rudd (Texas A&M University), and Bhoja Basnet (CIMMYT), J.-B. Sarazin (Asur Plant Breeding 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 Asur Plant Breeding (formerly 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 6 years. As of January 2017, 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 was the lead institution and will work closely with Texas A & M University, Kansas State University, Asur Plant Breeding 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 (with a one year no cost extension) 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.

We continue to screen the Nebraska and Texas breeding programs for anther extrusion. 2019 was an excellent year to study this trait with generally cool and moist weather during flowering. In 2019, we evaluated for the third year, 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 is being used in genome wide association studies to map QTLs for anther extrusion as these lines are already genotyped. 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 (females gape a few days before the males reach maximum pollen shed) and the male is an excellent pollinator as visually determined by anther extrusion. The best indicator of female receptivity appears to be gape angle and 100% gape date (when all the spikes are gaping). Both female traits can be visually scored. Other traits that were scored were duration of gaping, stigma exsertion, and gape closure. The female traits were highly correlated, so one or at most two could be used to select excellent female lines.

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.

We continue to use Croisor® 100 to make hybrids. We continue analyzing the data, removing the spatial variation, comparing reciprocal crosses, and estimating heritability and heterosis from our 25 x 26 crossing block with the emphasis on determining the genetics of heterosis. We successfully used the balanced missing design pioneered by our German cooperators for the 2017, 2018 and repeated it in 2019 crossing blocks. 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. To ensure that environmental hazards did not destroy the crossing block, we grew two crossing blocks (1 in NE and 1 in TX). Hybrid seed yields were much higher in 2019 than in 2018 due to the better weather conditions. We evaluated for the second year the hybrid yield trials (total of six locations (3 in NE and 3 in TX). As in the past, heterosis was present particularly in stressed environments showing climate resiliency of hybrid wheat. On the basis of the results of yield results, we developed specific hybrids trials with 3 replications to validate our heterosis in the augmented design research (needed due to the large number of entries in the hybrid yield trials, often > 800 plots). Finally, we completed the third year of a small experiment to study CHA rates and different adjuvants to reduce phytoxicity and the amount of chemical needed to sterilize wheat plants. In 2017, the trial was successful, but we were able to obtain more of the European surfactants/adjuvants for the 2018 and 2019 trials. The surfactants allow lower rates of the CHA to be used, hence less phytotoxicity. In the 2019 trial, we sprayed slightly early due to persistent rains. NI13706 was hard to sterilize all three years, while NE09517 seemed to be easier to sterilize. The window of CHA application is narrow and later spray applications need higher CHA rates to be effective. As part of our international collaboration, we grew a small hybrid trial developed in Germany. As expected, the German hybrids and parent lines were late developing compared to Nebraska lines. This year, the later German hybrids were severely affected by late heat stress as seen in dramatically lower grain yields.

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.

All of the parental lines have been genotyped, and the genomic analysis was completed to the point where we can predict which hybrids should be made to the highest levels of heterosis. The accuracy of predicting the yield of hybrid was higher in TX compared to NE locations. The high spatial-variation and low heritability values in NE influenced the quality of phenotype, which resulted in low prediction accuracy in NE compared to TX environments. This also indicates an opportunity for research and integrating digital phenotyping and additional field covariates to increase the accuracy of phenotyping large trials in NE. Further, the ~750 hybrids tested at three locations in NE and TX in 2018 and 2019 were used as training sets and a hybrid yield of ~11,000 hybrids was predicted for NE and two mega-environments in TX. From these predictions, the top 1,000 predicted hybrids were selected initially using yield. Subsequently, we dropped ~750 hybrids based on whether a successful hybrid could be made using male and female key parental traits (anther extrusion and gape angle) and the nick scores (difference in the anthesis date of male and female line in a cross). Subsequently, we designed and planted a crossing block in NE and TX in 2019-2020 based on the predicted hybrids we want to test in 2021-22. The crossing block comprises ~210 high-yielding crosses and ~40 low-yielding crosses predicted and selected as described previously. Besides making the potential high-yielding hybrids that were previously not made, this crossing block will also help make hybrids to validate the genomic predictions. To the best our knowledge, we are the only team in the public-sector for wheat in North America where breeding combined with genomic selection is being used in a practical manner to develop superior hybrids for target environments.

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.

The evaluation of biparental mapping populations for restorer (Rf) genes were completed. While some previously known Rf genes were found, additional novel Rf were mapped suggesting that this population based on one of the best restorer lines in Australia was a rich source of pyramided restorer genes. Work continues to develop through crossing and evaluation, modern winter and spring wheat restorer lines and male sterile lines using the *Triticum timopheevi* cytoplasm. The CIMMYT R-lines are available from CIMMYT.

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.

<u>Development of CMS tester lines</u>

A new set of *T. timopheevii* CMS tester lines have been developed at CIMMYT via repeated backcrossing. After BC4 in the greenhouse, the A-Lines are being multiplied in isolation using corresponding B-Lines. These A-lines will be useful to produce and test CMS hybrid with proven R-lines, and they can also be used to study the seed production efficiency under different production schemes in the future.

Texas: We will continue to backcross our CMS lines to their maintainers in a greenhouse at College Station. We have been making crosses between adapted Texas male parents to several restorer sources to develop R-lines. The joint effort on mapping restorer genes will be utilized in our marker-assisted backcrossing efforts and is expected to help us pyramid restorer genes. A minimum of three different restorer genes is needed for full restoration of fertility in the A-lines.

Nebraska: We will continue to make backcrosses to our elite lines to develop CMS females and work with increasing female seed in the field. We have made a number of spring R-line crosses to NE winter males and are selecting for winterhardiness, male fertility, and agronomic performance. The progeny of our first set of R-lines x B-line crosses to create new R-lines in an adapted winter background are in the F_8 generation. Some of the putative modern R-lines are fertile as a selfed line (e.g. the restorer genes are homozygous), but only convey partial fertility when crossed onto an A-line (e.g. the restorer genes are heterozygous). Other putative modern R-lines are fertile as a selfed line (e.g. the restorer genes are homozygous and convey full fertility when crossed onto an A-line (e.g. the restorer genes are heterozygous) indicating they have potential as hybrid parent R-lines. We are also intermating putative R-lines to determine if we can pyramid Rf genes. Having molecular markers will greatly facilitate this research.

<u>Comprehensive characterization of restorer-of-fertility-like gene family in bread wheat for identification of novel alleles for fertility restoration</u>

Producing hybrid seeds efficiently is a critical prerequisite of hybrid crop breeding. The cytoplasmic male sterility (CMS) system is one of the hybrid production systems used in cereals which involves three lines, a cytoplasmic male sterile line with no restorer alleles (sterility occurs due to the specific interaction between mitochondrial and nuclear genes), a maintainer line (an alloplasmic line of the male sterile line in a fertile cytoplasm, hence fertile) to produce and maintain seeds of sterile line, and a restorer (R) line (that carries the restorer-of-fertility (Rf) alleles to restore fertility of sterile line and produce seed). With the availability of genome sequence and genotyping using next-generation sequencing, it is now possible to systematically characterize the restorer-of-fertility-like (RFL) gene family and identify novel alleles for fertility restoration. We identified 203 RFL genes and an additional 13 putative genes in the wheat genome. These genes were present in clusters. Nearly 86% lacked introns and ~70 were targeted to mitochondria. Using the GBS-derived SNPs, four subgroups were identified in a historical collection of R-lines (a.k.a CARGILL collection) and many of the advanced R-lines (likely carrying multiple Rf alleles) clustered in the same subgroup indicating their similar ancestry. Four SNPs (likely restorer alleles) were identified and the genes underlying these SNPs had the highest expression in pistillody stamens (male sterile condition), which makes these SNPs potential candidates for functional alleles. Three of these four SNPs are located on chromosomes that have no previous reports of restorer locus suggesting these are novel. All four SNPs were converted to KASP markers and two are currently being tested in ~9 independent crosses. This study presents a novel approach to identify likely Rf alleles in crop species as well as identification and validation of novel Rf alleles in the wheat genome.

14. Understanding Low Phytic Acid Response in Wheat. B. Kayitmazbatir (formerly Cetindere), R. A. Graybosch, S. Sattler, D. Rose, and P.S. Baenziger

Winter wheat (*Triticum aestivum L.*) is a major staple for human nutrition. However, the antinutrient phytic acid limits the nutrient absorption and bioavailability of the essential nutrients of iron and zinc. Low phytic acid mutant (*lpa1-1*) reduces the phytic acid content in the aleurone layer of wheat. In wheat breeding programs, grain protein concentration (GPC) is one of the crucial traits, because it affects the nutritional value and bread-making properties of wheat. The grain protein content-B1 (*Gpc-B1*) gene regulates positively for increasing protein, iron, and zinc concentrations in the grain. Recombinant inbred genotypes (RILs) were developed that contain both *lpa1-1* and *Gpc-B1* to improve nutrient availability. RNAseq was performed on developing seeds at three stages to determine how *lpa1-1* and *Gpc-B1* affect global gene expression relative to their wild type (WT) counterparts during the critical period of grain filling. The goal of the study is to identify the gene that is responsible for the reduction of phytate in the *lpa1-1*. This study identified a novel gene on chromosome 5A that might significantly be responsible for low phytate phenotype as a candidate gene. Different expression patterns of the mutant lpa-GPC genotypes than lpa-WT and WT-WT genotypes did not explain the QTL identified by Venegas, et al. (2018) on chromosome 4D indicating that another genetic mechanism may be involved with the phenotype affected by that QTL.

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, however it is a soft wheat and will need an identity preserved market. Two new lines (NHH17450 and NHH17612) have been approved by BASF as having sufficient herbicide tolerance for release if their agronomic performance warrants release. Both lines are in regional nursery testing and being increased for statewide testing in 2020. We have access to the COAxium trait and breeding for tolerance to Aggressor® herbicide. 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 2018, we planted more than 750 doubled-haploid lines created in collaboration with Limagrain and are evaluating lines at Mead. Fortunately, they survived the flooding, but were severely damaged, so we harvested them for seed (not agronomic performance) and replanted in 2019. We expect many good lines in this group. So far one line LCS Link has been released and a second line has been licensed from this cooperative effort. In addition, it opened the door for marketing a winter triticale by Limagrain and LCS Bar was licensed to them, as was LCS Valiant. 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).

This population was planted in the field for the first time in 2019 and will be evaluated by Mr. Emre Karahan, a new student on the project. Our cooperation on hybrid wheat is only possible due to a collaboration with Asur Plant Breeding in France and we are truly grateful that we are able to cooperate with them. Our agreements have been extended for the next three years. We have additional research agreements with other companies for sharing germplasm to testing lines to marketing lines nationally and internationally.

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 with 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 are sad to report that Paramount Seed Farms (a commercial seed company) went bankrupt and has recently been purchased. They no longer have the exclusive rights to 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 2014-18, but P-845 (released in 2013). However, numerous new lines look very promising and we expect to release NB15420 in 2020 if it continues to perform well. If released, NB15420 will be a non-exclusive release. 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 (specifically 2-row winter barley lines). 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. In 2019, Mead was lost to floods and Hays to a storm just before harvest which broke heads off and lodged the plants.

The data for 2019 are:

		Stillwater	Lincoln	Sidney		Rank	Test	Flowering	Plant
					Average		Weight	Date	Height
Name	Pedigree	Yield	Yield	Yield	Yield			Days after	
		Lbs/a	Lbs/a	Lbs/a	Lbs/a		Lbs/bu	Jan. 1	inches
NB16412	NB09433/NB09440	3803	4427	4168	4132.7	1	46.6	140.2	30.9
NB17411	NB09410/NB09432	2879	4546	4657	4027.3	2	46.9	141.2	34.6
NB18429	NB11414/TAMBAR 501	2683	4255	4881	3939.7	3	44.7	142.9	30.8
NB17401	NB08428/NB09410	2425	4921	4449	3931.7	4	48.2	143.1	36.9
NB18411	NB10420/TAMBAR 501	3674	3936	4107	3905.7	5	45.3	138.2	29.0
NB18439	NB09434/NB09410	2728	3623	5010	3787.0	6	46.8	144.4	31.0
NB15441	NB99845/NB08410	2733	4094	4376	3734.3	7	45.1	139.8	29.4
NB14430	NB07443/NB99845	2626	4469	4100	3731.7	8	45.1	139.2	28.1
NB18422	NB09427/NB10444	2341	3864	4949	3718.0	9	46.4	145.3	30.8
NB14404	NB07410/NB018187	2501	4437	4158	3698.7	10	45.2	139.2	29.8
NB18408	NB10409/NB11430	2506	4081	4487	3691.3	11	45.5	142.0	32.3
NB18406	NB09427/NB10440	2051	4211	4673	3645.0	12	45.2	144.3	32.4
NB11416	P-721//VA01H-5/Sangregado"S"//VA90-42-56	3363	4021	3496	3626.7	13	44.3	139.8	29.0
NB12437	NE98936/NE97891/NB04436=(NE97971/NE	2182	4158	4520	3620.0	14	43.8	141.9	30.5
NB15420	NB99845/NB08410	2671	3998	4159	3609.3	15	45.6	139.2	29.9
NB99845		3105	4039	3639	3594.3	16	45.1	136.2	30.4
NB17415	P-954/NB09410	2230	4164	4361	3585.0	17	47.2	140.8	32.6
NB14422	NB99845/NB05419	2670	4217	3823	3570.0	18	43.5	140.8	28.0
P-954		2193	3936	4565	3564.7	19	46.4	140.6	31.8
NB18416	NB11432//NB03437/NO71SSD_51	2623	4067	3973	3554.3	20	44.5	139.1	35.0
NB17431	NB07411/NB09410	1622	4325	4712	3553.0	21	45.4	143.1	35.1
NB12434	NE98936/NE97891/NB03439=(Perkins/88Ab	3011	3484	4151	3548.7	22	46.5	141.0	29.1
NB11414	P-721//VA01H-5/Sangregado"S"//VA90-42-56	2450	3686	4500	3545.3	23	44.75	141.9	31.8
NB18401	NB08428/NB11418	2153	4011	4409	3524.3	24	45.6	141.1	30.5
NB18417	NB10403/NB09410	2126	3909	4533	3522.7	25	44.7	140.2	33.5
NB17409	NB09410/NB09432	2220	3658	4583	3487.0	26	47.0	144.5	33.1
NB16433	NB08410/3/NB08410//NB06432/H. spontan	2630	4177	3561	3456.0	27	45.4	138.3	32.0
NB15415	NB99845/NB08410	2142	4558	3622	3440.7	28	46.7	139.4	29.6
NB18435	NB11431//NB03437/NO71SSD_51	2169	3837	4281	3429.0	29	43.8	141.1	28.7
NB17436	NB09432/NB10434	2897	3700	3685	3427.3	30	37.4	140.9	32.3
NB10444	Unkown	2303	3916	4057	3425.3	31	43.2	142.0	34.7
NB15417	NB99845/NB08410	2496	4009	3657	3387.3	32	46.7	139.3	30.1
NB15442	NB99845/NB08410	2495	3829	3732	3352.0	33	46.5	138.3	29.5
NB18423	NB10403/NB09410	2910	3334	3799	3347.7	34	45.3	141.3	34.1
NB15419	NB99845/NB08410	2352	2854	4552	3252.7	35	46.0	141.6	31.4
NB18440	NB09434/NB09410	2487	3347	3848	3227.3	36	47.6	146.7	32.0
NB18432	NB11419/NB09410	2597	3165	3862	3208.0	37	47.3	142.4	28.7
NB14428	NB07443/NB99845	2931	3446	3001	3126.0	38	42.2	140.9	28.5
NB16411	NB08411/NB09441	2436	3713	3029	3059.3	39	45.2	139.5	33.9
NB18428	NB11414/TAMBAR 501	2463	3435	3205	3034.3	40	45.0	137.4	30.9
GRAND MEAN		**2571.97**	**3946.44**	**4133.31**	**3550.5**		**45.3**	**140.98**	**31.3**
LSD		795.87	729.1	615.46				2.43	
CV		18.93	11.3	9.1				1.05	

What is interesting in this data is that the checks P-845 (formerly NB99845) and P-654 (formerly NB86954) were in the lower half of the trial indicating we had many superior lines. With additional testing and seed increases, we expect a number of them to be released.

In 2018, Sidney was lost to storms. The data for 2018 are:

			Lincoln		Mead		Colby KS		Stillwater OK			Average	
	Yield	Height	Flowering	Height	Yield	Flowering	Yield	Test Wt	Yield	Flowering	Height	Yield	Rank
			Data			Data				Data			
	lbs/a	in	D aftr Jan.1	in	lbs/a	D aftr Jan.1	lbs/a	lbs/bu	lbs/a	D aftr Jan.1	in	lbs/a	
Name	aadn_ln18	htin_ln18	hdjd_ln18	htin_m18		hdjd_m18	ydlb_cks18	twt_cks18	ydlb_ok18	hdjd_ok18	htin_ok18		
P-954	3028	23.7	142.2	24.6	2297	145.5	2136	45.3	4248	111.7	28.3	2342	24
NB10444	2974	27.7	142.8	27.3	2330	147.3	2686	40.6	4163	112.4	29.0	2431	15
P-845	3456	25.0	137.0	25.4	2200	143.0	1862	42.1	3991	109.4	27.9	2302	27
NB11414	3196	24.7	139.6	22.9	2797	145.5	2296	43.0	3961	112.6	26.9	2450	13
NB11416	3356	25.3	138.5	25.4	2940	144.3	2248	45.1	3963	112.0	18.2	2501	7
NB12434	3090	24.7	140.9	23.5	2718	145.7	2149	48.0	4090	110.3	26.7	2409	17
NB12437	2880	25.0	142.8	25.6	2681	144.3	2901	43.0	4331	115.3	27.8	2559	4
NB14404	3571	26.3	137.4	24.3	2624	144.6	2049	43.2	4233	110.7	27.0	2495	9
NB14405	3147	27.3	142.6	28.3	2437	148.1	2633	44.2	3367	115.0	31.0	2317	25
NB14422	3823	24.0	140.6	22.7	2358	144.6	1982	41.9	4306	113.4	25.3	2494	10
NB14428	2852	24.0	142.3	24.5	1771	146.8	2146	42.8	4398	111.0	25.9	2233	30
NB14430	2819	24.3	139.6	23.4	2608	145.3	1929	47.3	4026	110.3	25.4	2276	29
NB15415	3490	25.3	140.0	25.9	2841	144.6	1985	49.7	4102	110.4	27.0	2484	11
NB15417	3162	25.3	138.8	26.9	2849	145.4	1930	45.7	4229	110.0	27.2	2434	14
NB15419	2829	24.7	141.5	26.3	NA	148.6	1978	41.7	4348	111.7	28.7	2289	28
NB15420	3508	27.7	137.0	26.4	3542	143.8	2095	46.4	4219	109.1	27.0	2673	2
NB15441	3199	25.0	139.6	26.4	3130	143.6	2158	47.1	4240	109.4	27.4	2545	5
NB15442	3362	26.3	139.9	25.1	2532	146.1	1948	45.8	4174	110.6	26.7	2403	19
NB16411	2732	31.0	137.0	26.8	2236	143.7	1748	46.1	2991	110.7	30.4	1941	37
NB16412	3153	25.7	141.5	25.3	2491	144.3	2215	44.5	4228	112.0	28.7	2417	16
NB16433	3024	26.7	138.5	25.9	2103	144.5	1877	45.5	3852	108.0	27.8	2171	31
NB16434	2245	26.0	140.9	23.5	1851	145.8	1671	42.5	3606	108.6	28.1	1875	38
NB16437	2506	28.3	137.2	25.3	2395	144.8	1981	42.2	3920	108.7	29.1	2160	32
NB17401	2783	28.7	142.0	26.8	3044	147.0	2453	46.8	4243	114.0	32.4	2505	6
NB17403	2865	28.0	140.7	26.9	2289	145.1	1650	38.1	3679	109.7	26.7	2097	35
NB17409	3179	27.3	142.4	25.5	2571	148.2	2542	43.9	4214	115.0	29.8	2501	8
NB17411	3293	28.7	141.0	25.5	2417	147.6	2662	44.1	3890	115.3	21.0	2452	12
NB17412	2919	26.7	142.1	24.9	2263	149.7	2601	44.5	4119	116.0	30.2	2380	22
NB17415	3032	26.3	141.1	26.8	3192	145.9	2396	45.3	4185	111.3	28.7	2561	3
NB17419	2750	24.3	136.7	24.9	2285	143.2	1135	35.2	4013	109.0	26.0	2037	36
NB17422	2943	26.7	141.5	27.0	1623	146.9	2092	42.3	3863	112.6	18.8	2104	34
NB17423	2907	26.7	141.6	23.7	2296	147.1	2238	39.9	4576	111.0	24.9	2403	18
NB17427	2814	23.3	141.0	25.0	1663	146.8	1856	41.3	4202	108.6	26.7	2107	33
NB17430	3362	26.7	137.2	24.4	2690	142.7	1884	40.0	4006	109.0	28.2	2388	21
NB17431	3370	28.3	141.3	28.7	3418	145.7	2541	44.6	4135	113.3	30.0	2693	1
NB17435	2337	27.3	138.6	26.0	2028	143.0	1380	35.2	3589	110.0	19.3	1867	39
NB17436	2504	29.3	138.6	27.7	2368	144.4	2573	36.9	4533	111.0	31.7	2396	20
NB17438	3056	24.0	137.4	25.2	2623	142.8	1741	42.4	4149	109.2	26.6	2314	26
NB17443	1324	35.7	139.2	32.9	1102	143.9	1441	29.5	2644	114.4	34.5	1302	40
NB10425	3242	27.3	141.7	28.4	2110	145.5	2240	41.6	4182	112.8	30.8	2355	23
GRAND MI	3002.1	26.5	140.0	25.8	2454.2	145.4	2100.7	42.9	4030.2	111.4	27.3	2316.6	
LSD	402.17	2.79	1.97	3.11	NA	2.29	442.78	4.87	433.81	1.17	9		
CV	8.19	6.48	0.86	7.37	8	0.96	12.89	6.95	6.58	0.65	20.2		

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 three year data for 2017-2019 are presented below:

Name	COLBY	Mead	Lincoln	Sidney	AVG	Rank	Hdate	Height	est Weigh
	Yield	Yield	Yield	Yield	Yield		Flowering		
	lbs/a	lbs/a	lbs/a	lbs/a	lbs/a		Date	inches	lbs/bu
							D after Jan.1		
NB15441	2158	5034.1	4259.3	4034.0	4145.2	1	134.1	27.9	45.4
NB15420	2095	4813.8	4618.0	3777.5	4134.4	2	133.5	27.8	45.9
NB15415	1985	4665.0	4652.7	3635.5	4070.5	3	134.0	27.9	47.3
NB11414	2296	4425.6	4199.0	4222.5	4031.4	4	135.7	27.9	44.3
NB12437	2901	4335.9	4034.0	3930.5	3986.1	5	136.9	27.9	44.0
NB15417	1930	4668.2	4450.7	3572.5	3955.2	6	133.8	28.2	45.6
NB14404	2049	4361.8	4532.0	3462.0	3954.5	7	133.8	27.4	44.7
NB14422	1982	3678.2	4722.0	3858.0	3915.6	8	135.6	25.7	43.4
NB11416	2248	4275.2	4410.0	3421.0	3847.6	9	134.5	26.0	44.2
NB15442	1948	4248.8	4342.7	3667.5	3843.2	10	134.2	27.3	45.4
NB12434	2149	4435.0	4101.7	3701.5	3838.3	11	134.8	27.1	46.7
NB16412	2215	3761.4	4249.7	3820.0	3824.9	12	134.8	28.5	44.5
NB14430	1929	4076.9	4292.3	3321.0	3765.2	13	134.2	26.1	46.0
NB10444	2686	3846.8	3906.7	3829.5	3749.5	14	136.3	30.2	42.9
NB16433	1877	3698.5	4280.3	3511.5	3667.4	15	133.4	28.7	45.6
P-845	1862	3487.0	4364.7	3471.5	3634.7	16	132.8	27.6	44.0
NB15419	1978	5800.0	3699.0	3859.0	3633.3	17	135.6	28.7	44.8
P-954	2136	3480.7	3788.7	3738.5	3576.8	18	135.7	28.3	46.2
NB16411	1748	3599.6	3872.3	3433.0	3422.3	19	133.8	30.5	44.8
NB14428	2146	3631.5	3975.7	2986.5	3392.5	20	135.4	26.5	42.9
Average	2116	4216	4237.6	3663	3819		134.6	27.8	44.9

These data are interesting because the averages are developed in two ways. The first average (*) is over each trial (N=8) and the second is averaged (**) over locations (N=4) . 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, a project is the people who make this research possible. Drs. Zakaria Aj-Alouni and Ibrahim Salah El-Baysoni finished their project as visiting scientists. Both returned home to Jordan and Egypt, respectively. Dr. Ibrahim Salah will return in 2020 and currently coordinates our Egyptian nurseries while on the faculty at his university. Dr.Bolor Gold (from Mongolia) and Mr. Mujahid Alam (from Pakistan) joined the project as visiting scientists. Ms. Betul Kayitmazbatir (formerly Cetindere) and Ms. Hannah Stoll successfully completed their M.S. degrees. Betul returned to Turkey and is part of the national wheat breeding effort. Hannah began a Ph.D. program at the University of Minnesota. Dr. Sarah Blecha successfully completed her Doctor of Plant Health Degree and accepted a position with the USDA-ARS at the University of Minnesota. Mr. Emre Karahan and Ms. Nichole Miller joined the program and began M.S. degrees working on hybrid wheat. Mr. Felipe Sperotto joined the program as a research technician. We are extremely grateful for the excellent work that the team has done and continues to do.

X. Publications from the Project:

1. Bhatta, M., P.S. Baenziger, B.M. Waters, R. Poudel, V. Belamkar, J. Poland, and A. Morgounov. 2018. Genome-wide association study reveals novel genomic regions associated with 10 grain minerals in synthetic hexaploid wheat. Int. J. Mol. Sci. 20, 3237.

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11. Navrotskyi, G. Guo, P.S. Baenziger, L. Xu, and D. Rose. 2019. Impact of wheat bran physical properties and chemical composition on whole grain flour mixing and baking properties. J.Cereal Sci. 89: 102790. https://doi.org/10.1016/j.jcs.2019.102790

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22. Adhikari, A., A. M. H. Ibrahim, J. C. Rudd, P. S. Baenziger, and J.-B. Sarazin. 2020. Estimation of Heterosis and Combining Abilities of U.S. Winter Wheat Germplasm for Hybrid Development in Texas. Crop Science: Accepted

Summary:
In 2018-2019 season, 1,070,000 acres of wheat were planted in Nebraska (a record low) and 970,000 acres were harvested with an average yield of 57 bu/a (a record high) for a total production of 55,300,000 bu. In general, disease pressure was fairly low and mainly leaf rust with some pockets of Fusarium head blight. Wheat stem sawfly was prevalent in western Nebraska. In 2017-2018 season, 1,100,000 acres of wheat were planted in Nebraska and 1,010,000 were harvested with an average yield of 49 bu/a for a total production of 49,490,000 bu. 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. 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. Nebraska began retaking the variety surveys in 2015, however due to financial constraints did not do one since 2017. Using aggregate data from the Nebraska Crop Improvement Association, approximately 43% of the wheat planted acres were planted to certified seed of 46 different cultivars. The certified seed planted acreage will vary by cropping system and region with more save seed in regions where less seed of other crops are purchased. Approximately 44% of the certified seed was developed by companies, 44 % by the USDA-University of Nebraska and 12% from other public breeding programs. From seed sales, Ruth (ranked 3rd in certified seed sales) had an excellent year and should be adopted well in across NE. Settler CL, Robidoux, Freeman, and many of the commercially developed lines continue to be popular. The project formally released one new wheat line NE12561 which will be marketed through NuPride Genetics Network and named Siege (https://agronomy.unl.edu/Baenziger/annualreports/SiegeUNLSignedUSDA.pdf) and a second line in collaboration with Limagrain (LCS Valiant, https://agronomy.unl.edu/Baenziger/annualreports/ValiantUNLsignedUSDA.pdf and https://limagraincerealseeds.com/central-plains/hard-red-winter-wheat-seed/lcs-valiant/). LCS Valiant was sold in Fall 2019 to growers and the first certified seed for NuPride Genetics Siege will be available to growers in Fall 2020. Our first approved 2-gene Clearfield line (NHH144913-3 was discovered to have soft kernels and will need to be an indentity preserved wheat if it is marketed). It is currently being tested in traditional soft wheat states and may fit into eastern KS where soft wheat cultivars are currently grown. Two new hard red winter wheat lines, NHH17450 and NHH17612, both with hard texture and hard wheat quality were approved by BASF for release as Clearfield Plus cultivars. We are increasing seed of these lines for further testing and increase with the hopes they may be released.

Our next white wheat, NW13493 (derived from the cross SD98W175-1/NW03666), has been developed, but a key need is identifying a buyer for it. There is little doubt that if NW13493 were a hard red wheat, it would be released. It is a very high yielding, early, semi-dwarf with good winterhardiness and disease resistance (leaf, stem, and stripe rust; wheat soilborne mosaic virus). However, it is susceptible to wheat streak mosaic virus and Hessian fly. While it has good test weight, it tends to be slightly below average for grain protein content. It has very good end-use quality. One new forage triticale (NT14433) and one new winter barley line (NB15420) are under increase for possible release. Forage triticales have the larger market, but we have excellent grain types also. In barley, we are expanding our efforts in developing value-added winter 2-row malting types. Our work in developing herbicide resistant, scab tolerant, wheat streak mosaic resistant, and wheat stem sawfly resistant cultivars continues. Hybrid wheat and genomic selection continues to be a major part of our program. We continue to use our genomic tools to identify key traits and our access to chemical hybridizing agents to make experimental hybrids. Meshing what we learn from hybrid wheat development into variety development will play a key role in our future breeding effort.

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