IMPROVING SMALL GRAINS VARIETIES FOR NEBRASKA

2016 STATE BREEDING
AND
QUALITY EVALUATION REPORT

Report to the

NEBRASKA WHEAT DEVELOPMENT,
UTILIZATION AND MARKETING BOARD

P. S. Baenziger, Devin Rose, Dipak Santra, and Lan Xu

Key Support Staff:
Mitch Montgomery, Gregory Dorn, Richard Little,
Janelle Counsell Millhouse, Marc Walter, and Vern Florke

Graduate Students, Visiting Scientists, and Postdoctoral Scientists:
Vikas Belamkar, Madhav Bhatta, Khatiba Bibi, Rungravee Boontung, Amanda Easterly, Shamseldeen Eltaher, Nick Garst, Waseem Hussain, Caixia Liu, Amira Mourad, Mohamed Saadalla, Ahmed Sallam, Javed Sidiqi, Jorge Venegas, and Meng Yuan Wang

Key University of Nebraska Cooperators:
Tony Adesemoye, Jeff Bradshaw, Tom Clemente, Cody Creech, Ismail Dweikat, Kent Eskridge, Yufeng Ge, Gary Hein, Greg Kruger, Bryan Leavitt, Richard Perk Teshome Regassa, Shirley Sato, Brian Waters, Stephen Wegulo, Rodrigo Werle, and Brian Wardlow

Key Cooperators:
USDA-ARS
Robert Bowden, Guihua Bai, Ming Chen, Richard Chen, Lori Divis, Justin Faris, Robert Graybosch, Mary Guttieri, Yue Jin, Rob Mitchell, Do Mornhinweg, Matthew Rouse, Brad Seabourn, Satyanarayana Tatineni, and Steven Xu

Public Universities:
Amir Ibrahim and Jackie Rudd (TAMU); Pat Byrne and Scott Haley (CSU); Brian Arnall, Liuling Yan, and Brett Carver (OSU); Gurong Zhang, Jesse Poland, and Alan Fritz (KSU), Sunish Sehgal (SDSU), and G. F. Marais and Zhaohui Liu (NDSU)

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2016 STATE BREEDING AND QUALITY EVALUATION REPORT

I. INTRODUCTION

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

II. THE 2015-2016 NEBRASKA WHEAT CROP

1. Growing Conditions

The 2015-2016 growing season would be considered being generally good for production. Growing conditions included timely planting into generally good soil moisture leading good fall stands and growth. The fields were planted on time for their respective eco-geographic zones and fertilizer was generally applied before planting, though the expected prices for the crop lead to less inputs (fertilizer, pesticides) being used than when wheat is worth more. Stripe rust was prevalent throughout the state and fungicides were frequently used. Severe rain at harvest hurt some grain yield and quality.

2. Diseases

In spring and summer in 2016, the main disease was stripe rust (estimated to reduce state yields by 7%) which was found widely across Nebraska and adjacent states. Due to a prolonged fall with cool-to-moderate temperatures and abundant inoculum (spores), stripe rust was widespread across the state in fall-planted wheat. It was most severe in the Panhandle, but moderate-to-severe levels occurred in localized spots in wheat fields elsewhere in the state. As opposed to previous years and despite the additional costs of fungicides, many fields were sprayed with fungicides to protect yield. Fusarium head blight (FHB) was minimal in all FHB-prone wheat-growing regions of the state. Both incidence and severity of FHB in individual growers' fields were trace to low and DON levels were minimal or negligible. Leaf rust developed to moderate levels in some fields that were not sprayed, but was not as widespread as stripe rust. Low-to-moderate levels of *Septoria tritici* blotch, tan spot, and powdery mildew were present in some unsprayed fields. Moderate-to-severe levels of bacterial streak and black chaff were present at Mead (southeast Nebraska) in a breeding nursery where susceptible wheat lines were planted. In fungicide treated and untreated trials at Lincoln and Mead, the yield loss due to foliar disease were 37% (31.8

bu/a) and 26% (16.1 bu/a), respectively. Take-all was present at low levels in some fields especially in the western part of the state. 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. For these crops, bacterial streak was not as severe as in 2015. Soilborne pathogens, especially Fusarium and Rhizoctonia were not as widespread as foliar pathogens but they were a concern in 2016. As usual, they caused root and crown rots, uneven stand establishment, and bare patches. Dr. Tony Adesemoye is involved in an ongoing survey of the soilborne pathogens in Nebraska wheat, studies of pathogen diversity, and follow-up studies on their impact on and management with different varieties of wheat.

3. Insects

Nebraska continues to have small outbreaks of Hessian fly and the diseases vectored by aphids (barley yellow dwarf virus) or mites (e.g. wheat streak mosaic virus and others). The wheat stem sawfly continues to be pervasive throughout the Nebraska Panhandle. We concluded a third year of our field survey to monitor the status of this pest in Nebraska and have yet to find this insect east of the Panhandle. Wheat stem sawfly is found in measurable populations near Chappell, NE. To date, wheat fields in southwestern Nebraska seem to be free of this pest. We completed one year of study to evaluate the effect of a spring tillage (using a disc implement) operation on wheat stem sawfly survival in fallow and found no impact of either one or two passes with a disc implement. Through our wheat stem sawfly survey, we have measured high populations of *Bracon cephi* (a beneficial parasitoid that attacks the wheat stem sawfly) at some locations. In collaboration with Mitch Stevenson (UNL Rangeland Ecologist), we will conduct studies in 2017 to evaluate the landscape effects they may facilitate conservation efforts for this beneficial insect. Additionally, we continue to collaborate with plant breeders and plant biologists at UNL to evaluate unique sources of host plant resistance to this important pest.

4. Small Grains Production

In 2015-2016 season, Nebraskans planted 1,370,000 acres of wheat and harvested 1,310,000 acres with an average yield of 54 bushels/acre for a total production of 70,740,000 bu. The 54 bu/a yield was a record mean yield. This production much higher than the production in 2015, and similar to the production in 2013. In 2014-2015 season, Nebraskans planted 1,490,000 acres of wheat and harvested 1,210,000 acres with an average yield of 38 bushels/acre for a total production of 45,980,000 bu. The high level of planted acres not harvested is likely due to prevalence of winterkill in western Nebraska due to fluctuating temperatures that year. In 2013-2014 season, Nebraskans planted 1,550,500 acres of wheat and harvested 1,450,000 acres with an average yield of 49 bushels/acre for a total production of 71,050,000 bu. Despite continued genetic improvement, the main determinant in wheat production seems to be acres harvested, government programs, the price of corn, and weather (which also affects disease pressure and sprouting). This is an economic reality in understanding wheat yields and productivity in Nebraska. Barley or triticale acreages are not reported in the NASS surveys.

5. **Cultivar Distribution**

Nebraska began retaking the variety surveys in 2015. The variety distribution is remarkable in that no variety has over 10% of the acreage. In 2016, SY Wolf (7.4%), Winter Hawk (7.0%) Settler CL (6.9%) were the most widely grown varieties in Nebraska followed by Brawl CL Plus (5.0%), Overland (4.9%), Byrd (4.5%) TAM 111 (4.3%), and Buckskin (4.2%). An additional, 11 varieties were grown on less than 4% of the acreage. In addition, 2.4% were blends and 26% of our acreage were grown in varieties having individually less than 1% of the acreage. Of the reported varieties, we estimate 62% of Nebraska wheat acreage grew varieties developed by the collaborative USDA-ARS, University of Nebraska small grains breeding effort. It should be noted that many commercial lines do not report their seed production for proprietary reasons, so without the survey, it is impossible to know how much of those varieties are produced within the state. While no wheat listed below has all of the characteristics of an ideal wheat, the diverse wheat varieties provide the grower an opportunity to choose high yielding, high-quality wheat varieties that have resistance or tolerance to the diseases or insects prevalent in his or her region. Variety diversity is useful, as it should reduce genetic vulnerability to disease and insect pests.

III. NEW CULTIVARS

In 2016, no new wheat or barley cultivars were released. However, seven winter triticale (x *Triticosecale Wittmack*) lines were recommended for release in 2017. The seven lines: NT05421, NT07403, NT09423, NT11406, NT11428, NT12414, and NT12434, developed cooperatively by the Nebraska Agricultural Experiment Station and the USDA-ARS, were released in 2017 by the developing institutions. The lines were developed for grain or forage production primarily in the Great Plains and to provide triticale growers with greater diversity to select winter triticale lines for grain, forage, or cover crop. Moreover, the University of Nebraska has commercial triticale partners who have tested these lines in regions beyond Nebraska; thus our testing network extends to locations beyond Nebraska. In this way, the USDA-University of Nebraska collaborative project is using a "participatory plant breeding" procedure where the USDA-University of Nebraska works with commercial partners who decide which of the advanced lines do best for them using their selection and commercialization criteria. Proprietary data from our cooperators are not shown and only data developed from Nebraska are presented. The agronomic data on the lines are presented in Table 1. Previously released winter triticales 'NE426GT' and 'NE422T' are included in the tables for head-to-head comparisons of new releases to more established cultivars. NE426GT is targeted as a good grain and/or forage variety (Baenziger et al., 2005) whereas NE422T is marketed primarily for forage purposes and its lower grain yield increases cost of seed production (Baenziger and Vogel, 2002). In reviewing the forage data, no lines were significantly better than NE426GT, but two lines (NE11406 and NT12434) were significantly lower forage yielding than NE426GT. For grain yield, two lines (NT07403 and NT09423) were significantly better than NE426GT. No new line was significantly lower grain yielding than NE426GT. Hence most of the modern triticale lines were similar in forage yield and equal or better for grain yield to the currently available commercial lines. Considering other attributes such as flowering date, NE422T was significantly later than NE426GT which was expected. Only NT07403 was significantly earlier than NE426GT. The remaining lines were not significantly different from NE426GT. For plant height, NE422T, NT05421, and NT11428 were significantly taller than NE426GT, while NT07403 and NT12414 were significantly shorter than NE426GT. Triticale has few diseases in Nebraska and there are no regional nurseries, hence there is little disease or insect data to report. Historically, triticale is very resistant to most diseases commonly found in Nebraska, such as the rusts (incited by *Puccinia spp.*) and many of the virus diseases such as wheat streak mosaic virus, which is prevalent in western Nebraska. For example in 2012, NT05421, NT07403, and NT09423 were evaluated in Kenya using field races (TTKSK and its derivatives; David Marshall, personal communication) and had stem rust (incited by *P. graminis Pers.: Pers. f. sp. tritici* Eriks & E. Henn.) infections of 10%, 1%, and 1% with infection types of S, S, and S, respectively for the three lines, whereas in the same nursery 'Jagger' wheat (*Triticum aestivum* L.) ranged from 50% - 70% infection and infection type of S. NT05421, NT07403, NT09423, and Jagger were all rated for stripe rust (incited by *P. striiformis* Westendorp f. sp. *triticina*) as having an infection type of moderately susceptible. In 2013, NT11406 and NT11428 were evaluated for stem rust resistance in Kenya using field races and both lines were rated as being resistant whereas Jagger ranged from 15% - 60% infected with a susceptible infection type of dead (killed by the disease). Stripe rust was not present in 2013. In Nebraska, when leaf rust (caused by *P. triticina* Eriks,), stripe rust, or stem rust were present on wheat, NT05421, NT07403, NT09423, NT11406, NT11428, NT12414, and NT12434, would be considered resistant. In years of high infection of ergot (caused by *Claviceps purpurea* (Fr.) Tul.), NT05421, NT07403, NT09423, NT11406, NT11428, NT12414, and NT12434, have very low infections. During its selection, experimental lines with ergot are routinely discarded. Triticale is susceptible to bacterial streak disease (incited by *Xanthomonas campestris* pv. *translucens* (Jones et al.) Dye). There were no significant differences among the lines tested. Note bacterial streak disease was absent the year that NT12414 and NT12434 were evaluated, so no data are presented for those lines.

Considering each line separately, NT05421 is a winter triticale with prostrate growth habit in the winter. It was derived from a complex cross mainly involving NE422T which the final cross was made in 1999. The F_1 was grown in the greenhouse in 2000 and the F_2 seed was planted as a bulk at Lincoln, NE and harvested with a combine in 2001 and replanted that fall at Lincoln, NE as an F_3 bulk. In 2002, $F_{3:4}$ heads were snapped from the F_3 bulk and planted in Lincoln, NE that fall as individual short rows (approximately 75 cm long with 25 cm between rows). In 2003, based upon visual selection for the absence of disease, good straw strength, and agronomic appearance, the better rows were selected. The harvested seed was visually inspected for seed quality and ergot and those samples with poor seed quality (shriveled grain) and ergot were discarded. The remaining lines ($F_{3:5}$) were planted at Lincoln, NE in four row plots that were 3 m long with 25 cm between rows in the fall of 2003 and combine harvested in 2004. The center two rows were cut and threshed using a plot thresher. There was no further selection thereafter. Based upon grain yield, seed quality, and agronomic and resistance to disease, $F_{3:6}$ lines were advanced for planting in fall of 2004 and harvesting in 2005 in a multi-location trial at Lincoln (single replication), Mead (two replications), and Sidney, NE (single replication). The name NT05421 is derived from the line being selected in Nebraska (N) being a triticale (T) in 2005 (hence 05) and being derived from plot 421. Thereafter it was tested in multilocation trials with three replications at the same three NE locations. The plant color at boot stage is blue-green and the stem is without anthocyanin. The neck is moderately hairy and straight. The flag leaf is upright, not twisted, and with a waxy bloom. The auricle is colorless. The head is awned and the color is yellow. The seed is amber in color, oval, wrinkled, and with a large and long brush.

NT07403 is a winter triticale with prostrate growth habit in the winter. It was derived from the cross NE98T424/FLOOD//NT00418 which was made in 2001. The pedigree of NE98T424 is PRESTO/NE91T409 and the pedigree of NT00418 is RAH-123/NE94T409. The same breeding procedure as described for NT05421 was used beginning with the cross being made two years later. The plant color at boot stage is green and the stem is without anthocyanin. The neck is hairy and straight. The flag leaf is drooping, twisted and with a waxy bloom. The auricle is colorless. The head is mid-dense, clavate, awned, and the color is tan. The glumes at maturity are pubescent, mid-long, narrow, with a wanting shoulder. The beak is acute. The seed is amber in color, oval, slightly wrinkled, and with a large and long brush.

NT09423 is a winter triticale with prostrate growth habit in the winter. It was derived from the cross NE426GT/NT01417, which was made in 2003. The pedigree of NT01417 is NE85T121/NE87T148//RAH-123. The same breeding procedure as described for NT05421 was used beginning with the cross being made four years later. The plant color at boot stage is green and the stem is without anthocyanin. The neck is hairy and straight. The flag leaf is upright, not twisted and with a waxy bloom. The auricle is colorless. The head is mid-dense, fusiform, awned, and the color is tan. The glumes at maturity are glabrous, mid-long, narrow, with a wanting shoulder. The beak is acuminate. The seed is amber in color, ovate, wrinkled, and with a large and long brush.

NT11406 is a winter triticale with prostrate growth habit in the winter. It was derived from the cross NT04427//NE92T422/NE426GT sib/3/NT02458//CTM86.101/GWT 88-12 which was made in 2005. The pedigree of NT04427 is NE422T/TX95V711, the pedigree of NE92T422 is 85LT401/NE83T24, and the pedigree of NT02458 is RAH-123/NE90T413. The same breeding procedure as described for NT05421 was used beginning with the cross being made six years later. The plant color at boot stage is yellow-green and the stem is without anthocyanin. The neck is hairy and straight. The flag leaf is upright, twisted and with a waxy bloom. The auricle is colorless. The head is mid-dense, oblong, awned, and the color is yellow. The glumes at maturity are slightly pubescent, mid-long, and mid-wide with a wanting shoulder. The beak is obtuse. The seed is amber in color, oval, slightly wrinkled, and with a mid-size and short brush.

NT11428 is a winter triticale with prostrate growth habit in the winter. It was derived from the cross NE03T413/3/NT02458//CTM86.101/GWT 88-12 which was made in 2005. The pedigree of NE03T413 is NE426GT sib//TRICAL 2700. The same breeding procedure as described for NT05421 was used beginning with the cross being made six years later. The plant color at boot stage is green and the stem is without anthocyanin. The neck is hairy and straight. The flag leaf is upright, twisted and with a waxy bloom. The auricle is colorless. The head is mid-dense, fusiform, awned, and the color is yellow. The glumes at maturity are slightly pubescent, mid-long, and mid-wide with a wanting shoulder. The beak is obtuse. The seed is amber in color, oval, slightly wrinkled, and with a large and long brush.

NT12414 is a winter triticale with a prostrate growth habit in the winter. It was derived from the cross NT05433//NE426GT which was made in 2006. The pedigree of NT05433 is NE426GT/TX95VT7117. The same breeding procedure as described for NT05421 was used beginning with the cross being made six years later. The plant color at boot stage is blue green and the stem is without anthocyanin. The neck is moderately hairy and straight. The flag leaf is recurved, twisted and without to a very small waxy bloom. The auricle is colorless. The head is mid-dense, fusiform, awned, and the color is tan. The glumes at maturity are slightly pubescent, long, and mid-wide with a wanting shoulder. The beak is acuminate. The seed is amber in color, oval, slightly wrinkled, and with a mid-size and mid-long brush.

NT12434 is a winter triticale with prostrate growth habit in the winter. It was derived from the cross NT01451/NT05434 which was made in 2006. The pedigree of NT01451 is OMI-4MI-3MI/NE91T410//RAH-123 and the pedigree of NT05434 is NE98T424/PLAI. The same breeding procedure as described for NT05421 was used beginning with the cross being made six years later. The plant color at boot stage is blue green and the stem is without anthocyanin. The neck is hairy and wavy. The flag leaf is drooping, twisted and with a waxy bloom. The auricle is colorless. The head is mid-dense, oblong, awned, and the color is tan. The glumes at maturity are slightly pubescent, long, and wide with a wanting shoulder. The beak is acuminate. The seed is amber in color, ovate, wrinkled, and with a large and long brush.

The lines have been uniform and stable since 2014. Less than 2.0% of the plants were rogued from the Breeder's seed increase in 2014-15. The rogued plants were taller in height or were awnless. Up to 3% off types may be encountered in future generations. Husker Genetics (Nebraska Foundation Seed Division), Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, Lincoln, NE 68583 had Foundation seed available to qualified certified seed enterprises in 2015 with the first sale of certified seed in 2016. The U.S. Department of Agriculture will not have commercial seed for distribution. The seed classes will be Breeder, Foundation, Registered, and Certified. All lines will be submitted for plant variety protection under P.L. 10577 with the certification option. A fee will be assessed on all certified seed sales. Small quantities of seed for research purposes may be obtained from Dr. P. S. Baenziger and the Department of Agronomy and Horticulture, University of Nebraska-Lincoln for at least 5 years from the date of this release. In addition, a seed sample of each line has been deposited in the USDA-ARS National Small Grains Collection, Aberdeen, ID, and this seed is freely available to interested researchers.

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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).

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

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

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

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

Ruth continued to do well in a wheat trial. Below is the comparative data from the State Variety Trial for 2014-2016.

	State	Southeast				West Central				West			
Lines	Yield	Yield	Grain Vol.Wt	Prot.	Ht	Yield	Grain Vol.Wt	Prot.	Ht	Yield	Grain Vol.Wt	Prot.	Ht
2014-2016	bu/a	bu/a	lbs/bu	%	in	bu/a	lbs/bu	%	in	bu/a	lbs/bu	%	in
Freeman	57.1	63	55	13.8	35	66	55	13.5	32	45	59	12.3	30
Overland	52.9	56	56	13.7	37	61	57	14	35	44	60	12.6	32
Ruth	57.5	62	56	13.6	37	66	57	13.7	35	47	61	12.8	31
Wesley	49.4	52	53	14.4	33	61	55	14.3	32	38	59	13.6	28
Avg. All Entries	51.5	55	54	14.3	37	61	55	13.7	34	41	60	12.7	31
LSD (0.05)		12	ns	0.5	2	9	3	0.5	2	8	1	0.8	2

IV. FIELD RESEARCH

1. Increase of New Experimental Wheat Lines

With the release of new varieties Husker Genetics Brand Ruth, Overland, Camelot, Freeman, Goodstreak, McGill, Panhandle, Robidoux, and Settler CL over the past several years, most advanced current breeding lines are not expected to be released yet. However, a number of lines are planted in Yuma, AZ to begin their increases. Specifically, the following lines are under increase:
Wheat:
NE12561 (NI04420/NE00403)
NI12702W (N03Y2014/NW03681//NuHills 10005) –white wheat
NI13706 (NI02425/HV9W99-558//Robidoux)
NW13493 (SD98W175-1/NW03666) –white wheat
NE10478-1 (NI03418/Camelot)
Overland Fhb1 (Overland with *Fhb1* for scab tolerance)
NHH144913-3 (SETTLER CL/NE07457//Brawl CL) –two gene Clearfield line
NHH144922-1 (INFINITY CL/NE06545//Brawl CL) –two gene Clearfield line

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

Line	Grain Yield (kg/ha)				Grain Volume Weight (lbs/bu)			Anthesis Date (d after Jan.1)			Height (in)		
	Line	Freeman	%		Line	Freeman		Line	Freeman		Line	Freeman	
NE10478-1	58.5	55.8	105.0	**	59	55.7	**	137.3	138.4	**	36.3	37.3	**
Ruth (NE10589)	61.1	59.1	103.0	*	59.9	56.8	**	144	142.1	**	36.8	35.3	**
NE12561	56.9	57.2	99.4	ns	61	56.8	**	140.9	140.8	ns	35.8	35.8	ns
Robidoux	58.9	59.1	99.7	ns	59.4	56.8	**	143.3	142.1	**	36.8	35.3	**
NI12702W	58.0	59.9	98.4	ns	61.6	56.7	**	144.6	142.1	**	36.3	35.4	**
NI13706	59.3	57.2	104.0	*	60.5	56.8	**	139.8	140.8	**	34.9	35.8	**
NW13493	58.8	55.8	105.0	*	59.7	55.7	**	139.9	138.4	**	37.7	37.3	ns
Overland	55.4	59.1	93.7	**	59	56.8	**	145.6	142.1	**	37.2	35.3	**

Line	Grain Yield (kg/ha)				Grain Volume Weight (lbs/bu)			Anthesis Date (d after Jan.1)			Height (in)		
	Line	Freeman	%		Line	Freeman		Line	Freeman		Line	Freeman	
NE10478-1	58.5	55.8	105.0	**	59	55.7	**	137.3	138.4	**	36.3	37.3	**
Ruth (NE10589)	61.1	59.1	103.0	*	59.9	56.8	**	144	142.1	**	36.8	35.3	**
NE12561	56.9	57.2	99.4	ns	61	56.8	**	140.9	140.8	ns	35.8	35.8	ns
Robidoux	58.9	59.1	99.7	ns	59.4	56.8	**	143.3	142.1	**	36.8	35.3	**
NI12702W	58.0	59.9	98.4	ns	61.6	56.7	**	144.6	142.1	**	36.3	35.4	**
NI13706	59.3	57.2	104.0	*	60.5	56.8	**	139.8	140.8	**	34.9	35.8	**
NW13493	58.8	55.8	105.0	*	59.7	55.7	**	139.9	138.4	**	37.7	37.3	ns
Overland	55.4	59.1	93.7	**	59	56.8	**	145.6	142.1	**	37.2	35.3	**

Exp. Line	**Sr**	**Lr**	**YR**	**HF**	**SBMV**	**D.Bunt**	**Acid Soil**
NE12561	MR	R	MR	MR	R	S	MS
NI12702W	R/MR	MR	MR	S	MR	S	R
NI13706	MR	MR	MR	S	R	MR	R
NW13493	R	MR	MR/**MS**	S	MR	S	
NE10478-1	MR	MR	S	MR	R		S
Overland FHB1	MR	R	S	S	R?	S	
NH144913-3				S	R		
NH144922-1				S	R		

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

The following triticale lines are under increase: NT11406, NT11428, NT12403 (new), NT12434, NT13416 (new), and NT13443 (new). Triticale is a growing grain, forage, and hay crop market. There is little competition for winter hardy lines from other institutions and companies, hence we are increasing our program and our marketing capability to capitalize on our strengths.

2. **Nebraska Variety Testing**

Numerous entries were included in some or all of the locations in the Fall Sown Small Grain Variety Tests in 2016. Twelve dryland locations in Nebraska were harvested for yield data and the data for the lines grown across the state is presented below. Freeman had the year that was always expected since its release. Newly released Ruth also did very well. As expected, Scout 66 and Turkey were the lowest yielding lines in the trial. The average of Freeman and Ruth is 64% better than Scout 66 (released in 1966 or 50 years ago. Breeding has made and continues to make progress.

Thirteen dryland locations in Nebraska were harvested for yield data in 2015. Both irrigated sites were lost to bad weather. One surprise was how well Overland, despite being severely infected in many locations with stripe rust, did across Nebraska. However, many of the growers used fungicides on their fields and hence the State Variety Trials on farmers' fields were protected from stripe rust. NE10478 which is a very promising experimental line was also very susceptible to stripe rust again indicating the value of fungicides or that NE10478 continued to yield well under disease.

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

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

Dryland	Yield		Yield
Entry	bu/a	Entry	bu/a
Ruth (NE10589)	42.9	Freeman	39.9
NE10478	41.7	LCH13NEDH-5-59	39.9
Overland Ever	41.2	Overland Ever & Gau	39.8
Overland	40.8	NE09521	39.1
Overland Gau	40.6	NI10718W	39.0

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

In 2014, the top ten entries for dryland production (11 environments) were:

Dryland	Yield	Dryland(?)	Yield
Entry	bu/a	Entry	bu/a
Ruth (NE10589)	61.7	NE07531	58.7
LCS Mint	60.9	Freeman	57.8
Overland	59.5	Camelot	56.9
NE09521	59.4	T158	56.8
NE09517	59.3	NE10478	55.8

As would be expected, the two lowest yielding lines were Scout 66 (46.3 bu/a) and Turkey (47.8 bu/a), which were 25% and 23% lower yielding (respectively) than the highest yielding line. That Turkey had a higher yield than Scout 66 may be due to the late rains, which favored late cultivars.

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

In 2016, two irrigated yield trials were harvested (Chase and Box Butte counties). Numerous very high yielding lines were identified, but neither location had a line yielding over 100 bu/a. Also, considering the very high yields found in dryland (rainfed) wheat production, clearly irrigation boosted yields, but not at the same levels as have been seen in drier years. It was remarkable, how similar the yields at Chase and Box Butte counties were.

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

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

The top ten lines in 2014 were:

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

As compared to 2013 this trial would be considered very high yielding and it is interesting to see how the rankings change with the overall environmental level. When breeding for higher grain yield potential, irrigated wheat trials are very helpful.

In 2013, only the site at Hemingford was harvested.

The top ten lines in 2013 were:

	Yield		Yield
Entry	bu/a	Entry	bu/a
SY Wolf	114	NW07505	110
NE09517	114	Mattern	108
LCH08-80	112	T163	108
Anton	110	NI06736	108
Armour	110	Panhandle (NE05548)	107

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. NI06736). Interestingly, Panhandle, a very tall semi-dwarf wheat, did well in this trial, which may indicate that it has a higher potential than our conventional tall wheat cultivars, when the conditions are right.

As in the past, we have an experimental line irrigated nursery, which grows under irrigation in western Nebraska and under dryland conditions throughout the state. The goal of this nursery is to identify higher yielding lines under irrigation and under higher rainfall conditions, which periodically occur in Nebraska.

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

Some lines such NI14729 and NE14421 seem to do remarkably well under rainfed and irrigated conditions. A successful irrigated wheat will need to perform under less than optimal as well as optimal conditions to provide the grower with the stable production they should expect.

The data for 2015 are:

Name	Lincoln	North Platte	Alliance	Average	RANK	Winter Surv.	Anthesis Date	Height
	Bu/a	Bu/a	Bu/a	Bu/a		%	D after Jan.1	(in)
Antelope	59.5	33.3	31.8	41.53	21	98.6	140.8	33.2
Robidoux	45.8	41.0	38.8	41.87	19	79.2	141.3	35.8
NI08707	63.6	39.9	45.9	49.80	2	97.4	145.4	31.4
NI10718W	56.0	56.0	35.5	49.17	3	97.3	140.6	34.4
WESLEY	55.1	47.8	38.9	47.27	5	101.3	140.7	33.9
NW07534	53.7	42.7	34.7	43.70	10	99.6	141.9	33.4
NI12713W	48.5	36.1	29.4	38.00	24	98.6	140.1	35.5
NI13703	49.9	25.7	28.3	34.63	32	92.1	140.1	32.6
NI13704	52.9	24.6	26.0	34.50	33	99.8	140.1	31.8
Settler CL	62.8	34.4	33.9	43.70	11	100.1	140.9	34.3
NI13717	48.1	27.6	28.6	34.77	30	98.3	142.8	31.8
NI14719	37.3	20.6	12.2	23.37	39	95.7	141.4	31.7
NI14721	48.3	26.7	32.4	35.80	27	100.2	142.7	34.1
NI14722	50.0	36.3	40.3	42.20	17	100.7	139.1	30.2
WB CEDAR	59.2	37.9	30.0	42.37	16	100.6	138.6	28.0
NI14727	53.4	41.0	35.1	43.17	15	100.2	141.6	37.5
NI14729	65.2	63.4	44.9	57.83	1	100.4	141.9	36.6
NI14732	42.7	31.3	26.7	33.57	34	92.4	140.9	31.5
NI14733	32.2	32.4	31.3	31.97	35	91.4	144.5	36.5
NI14735	52.9	43.2	46.3	47.47	4	98.7	142.0	35.4
SY Wolf	49.3	32.3	24.1	35.23	29	87.4	142.5	30.9
NE07531	63.3	33.2	33.6	43.37	13	95	140.3	35.3
NI15701	46.6	35.1	44.5	42.07	18	85.7	143.9	34.4
NE15434	43.0	55.2	43.1	47.10	8	93.6	144.7	35.1
NI15702	30.6	26.5	10.5	22.53	40	58	142.7	33.4
NI15703	45.4	22.1	21.0	29.50	36	95.8	149.3	35.5
NE15420	52.7	39.4	37.7	43.27	14	85.9	143.7	30.2
NI15704	48.2	31.6	45.2	41.67	20	85.8	143.4	29.7
NI15705	41.1	38.0	38.0	39.03	23	82.9	145.6	29.8
NI15706	36.6	40.2	30.0	35.60	28	77.4	141.4	32.5
NE15484	56.1	33.8	22.5	37.47	25	92.8	144.1	38.7
NI15707	53.8	19.3	31.1	34.73	31	90.7	138.8	30.3
NI15708	38.2	20.2	22.8	27.07	38	79	142.4	29.4
NI15709	52.3	46.0	32.4	43.57	12	89.2	145.1	33.1
NW15677	57.1	48.4	36.2	47.23	6	93	142.6	31.8
NI15710	53.7	47.3	38.8	46.60	9	94	141.3	35.1
NI15711	61.6	38.1	23.4	41.03	22	99.3	139.4	30.6
NI15712	54.2	25.3	30.9	36.80	26	96.2	141.1	30.2
NE15558	32.9	36.4	16.2	28.50	37	90.5	141.2	32.0
NI15713	58.9	42.5	40.3	47.23	6	94.1	142.4	35.3
Alpha level	0.05	0.05	0.05			0.05		
CV	13.2	21.6	13.9			9.8		
GRAND MEAN	50.32	36.32	32.31			92.71	142.08	33.04
Heritability	0.59323	0.56512	0.77265			0.36415		
LSD	10.9	12.8	9.1			14.8		

The data from 2014 are:

entry	Name	Dryland Lincoln Yield bu/a	Dryland Nplatte Yield bu/a	Dryland Alliance Yield bu/a	Dryladn Average Yield bu/a	Rank	Irrigated Hemmingford Yield bu/a	Rank	Test Weight Average lbs/bu	Height Average in
1	Antelope	68.2	39.6	57.1	54.97	31	113.6	13	60.25	32.23
2	NI04421	78.9	41.2	54.8	58.30	17	83.7	39	58.70	34.05
3	NI08707	78.6	49.6	63.4	63.87	2	116.7	12	58.30	32.40
4	NI09707	74.1	46	64.5	61.53	6	103.1	33	59.85	31.80
5	NI10718W	73.6	44.5	60.9	59.67	8	105.8	29	57.85	33.30
6	NI10720W	80.9	49.4	44.1	58.13	18	108.5	25	59.25	34.53
7	WESLEY	71.1	46.9	59.9	59.30	10	110.1	22	59.00	30.95
8	NW07534	69.9	51.1	53.1	58.03	20	120.4	5	59.00	31.33
9	NI12713W	66	44.6	53	54.53	33	122.2	4	60.45	33.75
10	NI13703	70.2	39	57.1	55.43	30	91.7	36	60.15	32.73
11	NI13704	65.7	37.2	63.9	55.60	29	117.9	10	60.40	31.83
12	NI13705	63	42.3	51.8	52.37	40	110.3	21	61.00	32.98
13	NI13711	70.5	42.5	57.3	56.77	25	100.7	34	60.25	33.15
14	NI13713	69.8	40.2	48.7	52.90	37	104.5	31	58.80	31.55
15	Settler CL	72	47.4	56.6	58.67	16	113.5	14	58.85	32.40
16	NE09481	68.7	44.5	44.1	52.43	39	91.3	37	59.25	31.23
17	NI13717	71.6	48.9	65.8	62.10	5	125.6	1	59.50	33.83
18	NI13720	72	39.6	51.6	54.40	34	113	16	59.60	30.33
19	NI14719	64.3	44.5	55.9	54.90	32	119.7	7	59.50	29.88
20	NI14720	62	47.7	67.5	59.07	14	112.4	17	58.35	32.93
21	NI14721	72.3	53.1	69.4	64.93	1	110.6	19	59.60	33.35
22	NI14722	72.1	42.1	54.9	56.37	28	118	9	59.00	30.00
23	NI14723	70.5	44.1	63	59.20	12	108.2	26	61.45	32.48
24	NI14724	69.7	39.7	64.8	58.07	19	117	11	59.95	35.33
25	Anton	69.6	41.9	60.4	57.30	23	108.6	24	58.40	31.55
26	WB CEDAR	64.7	38.4	54.7	52.60	38	110.6	19	59.70	28.85
27	NI14727	76.5	41.6	59.5	59.20	12	118.1	8	59.95	34.90
28	NI14728	70.6	42.2	49.2	54.00	36	113.1	15	59.15	31.73
29	NI14729	72.9	48	66.4	62.43	4	108.7	23	60.55	34.08
30	NI14730	74.1	39.8	56.6	56.83	24	111.7	18	60.10	33.93
31	NI14731	70.2	46.5	55.7	57.47	22	106.8	27	59.00	34.93
32	NI14732	66.6	44.4	52.2	54.40	34	120.2	6	58.10	31.13
33	NI14733	68.7	46.9	72.7	62.77	3	122.8	3	59.50	36.23
34	NI14734	75.3	40.2	53.9	56.47	26	87.6	38	58.55	34.45
35	NI14735	74.5	46.3	57.3	59.37	9	94.4	35	59.25	33.33
36	NI14736	75.7	44.1	49.5	56.43	27	82.9	40	58.40	33.68
37	NI14737	74.9	45.6	53.3	57.93	21	104.8	30	58.75	32.25
38	NI14738	68.6	45	63	58.87	15	106.1	28	60.25	30.98
39	NI14739	61.8	50.8	65.1	59.23	11	103.7	32	58.70	30.03
40	SY Wolf	73.6	47.9	62.8	61.43	7	125.1	2	59.20	32.03
	GRAND MEAN	70.84417	44.38	57.89333			109.1			
	LSD	7.59559	6.81723	10.38016			19.1			
	CV	6.59576	9.3951	11.0302			10.7			
	Heritability	0.36551	0.34889	0.4305			0.3			

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

	Linc.	N.Platte	Alliance	**Average**	**Dryland**	**Alliance IRR**	**IRR**	Hdatre	Height	Test Wt
	Yield	Yield	Yield	**Yield**	**Rank**	Yield	**Rank**	Days after		
	bu/a	bu/a	bu/a	**bu/a**		bu/a		Jan. 1	(in)	(lbs/bu)
Antelope	64.9	42.3	47.4	51.5	14	105.7	7	140.8	33.4	61.2
Robidoux	69.1	48.1	53.3	56.8	5	95.1	15	141.0	35.0	61.3
NI10718W	66.7	61.0	49.6	59.1	3	104.5	8	140.7	34.0	58.6
NI13703	62.1	42.5	48.8	51.1	15	92.9	16	139.5	33.3	60.8
NI13717	63.6	48.8	48.0	53.5	10	110.0	4	140.7	33.6	60.3
NI14722	63.2	49.0	52.5	54.9	7	111.1	3	139.2	30.9	62.0
NI14727	64.6	48.1	46.3	53.0	11	101.6	12	141.8	36.3	60.9
NI14729	73.3	69.8	58.1	67.1	1	109.7	5	142.5	35.8	61.9
NI14732	60.4	47.6	42.1	50.0	16	107.1	6	139.8	32.2	59.7
NI14733	57.6	46.1	52.2	52.0	13	104.1	9	142.0	36.8	60.3
NI14735	62.1	54.9	52.6	56.6	6	95.3	14	140.8	34.5	60.1
NW07534	67.4	53.1	50.4	57.0	4	112.2	2	141.8	32.7	60.8
Settler CL	66.3	51.9	45.6	54.6	8	101.8	11	140.4	33.4	60.4
SY Wolf	69.5	46.5	46.3	54.1	9	114.9	1	141.0	31.9	60.9
WB CEDAR	62.7	48.0	46.1	52.3	12	100.6	13	139.2	29.5	60.7
WESLEY	66.8	60.3	50.7	59.3	2	101.8	10	140.9	32.4	59.3
Average	**65.0**	**51.1**	**49.4**	**55.2**		**104.3**		**140.8**	**33.5**	**60.6**

4. **<u>Nebraska Intrastate Nursery:</u>**

The 2016 Nebraska Intrastate Nursery (NIN) was planted at eight locations in Nebraska: Lincoln, Mead, Clay Center, McCook (added due to generous support from Ardent Mills), North Platte, Grant (added due to a generous gift from Marvin Stumpf), Sidney, and Hemingford. In addition, two replications at Lincoln and Mead were sprayed three times with fungicides to control disease, while two replications were not treated which allowed a comparison of diseased vs. largely disease free genotypes. The sites at Grant, McCook, and Alliance were also sprayed with a single application of fungicide. The lower yields at unsprayed Mead, unsprayed Lincoln (28.9 bu/a), and Clay Center were due to disease (leaf and stripe rust, Fusarium head blight, and various leaf blotch infections. The fungicide treated plots at Lincoln and Mead prevented disease losses of 38 and 26%, respectively.

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

In 2015 Nebraska Intrastate Nursery (NIN), fifty-one cultivars were analyzed for wheat quality in kernel characteristics, milling attributes, ash and protein contents, dough rheological and bread-making properties.

There were significant differences in kernel characteristics among these cultivars. The kernel hardness indexes were 49.9±9.7. 37% cultivars including Cheyenne and Settler CL were classified as HARD, 51% cultivars include Goodstreak, Wesley, and Overland were MIXED, and the remaining 12% of cultivars were SOFT. The wheat kernel hardness indices were lower than normal ranges, probably due to weathering of the grain at harvest. The kernel diameters and weights were 2.8±0.1 mm and 35.7±2.4 mg, respectively. All cultivars, including checks had large diameter (≥ 2.4 mm) and weight (≥ 30.0 mg). A few samples (8%) had large kernel hardness deviation (> 17), no samples had diameter deviation (> 0.4), and a lot of samples (80%) had large weight deviation (> 8) in 300 kernels.

There were significant differences in milling properties among these cultivars. The flour, bran and short yields were 72.2±7.8%, 25.6±1.5%, and 2.3±0.5%, respectively. Except of NE14419, all other cultivars including checks produced high flour yield (≥ 68.0%). The bran, short and milling rates were 3.3±0.9, 3.2±0.9, and 3.4±0.9, respectively. Most cultivars (88%) including checks gave fair or better bran cleaning and milling performance. The kernel hardness indexes were significantly positive with short yield and bran cleaning rate, and protein contents.

There were significant differences in ash and protein contents, respectively, among these cultivars. The ash contents of white wheat (WF)at 14% mb were 0.41±0.04%. All cultivars including checks had lower ash content (< 0.50%). The protein contents of whole wheat (WW) at 12% mb and of WF at 14% mb were 14.3±0.8% and 12.8±0.8%, respectively. All cultivars including checks had higher protein contents in WW (> 12.0%) and in WF (10.0%). After milling protein contents were lost 1.1±0.7%. The protein contents of WF were correlated positively significantly with that of WW. The flour protein was correlated significantly dough rheological and bread-making properties.

There were significant differences in dough rheology among these cultivars. The flour water absorptions (abs) at 14% mb were 65.8±1.6%. All cultivars including checks had higher water abs (> 62.0%). The peak times (PT) were 4.6±1.2 min. Except Overland, Scout 66, Goodstreak, NE12561, NI13706 and NE13425 which had lower dough extensibility (< 3.0 min), all other cultivars including checks had higher dough extensibility (3.0-7.0 min). The peak torques (PQ) were 48.0±3.2 %TQ. Except 8 cultivars (NE06545, NI04421, NE13604, NE13672, LCH13NEDH, NE14434, NE146.63, and NE14700) had lower dough strength (< 45.0%TQ), all other cultivars including checks had stronger dough strengths (45.0-55.0 %TQ).The total area (TA) in 8 min and tolerance rates (TR) were 110±14 %TQ·min and 3.6±1.0, respectively. The TA was correlated significantly positively with TR. Eight cultivars had low dough resistances for mixing (TA < 100 %TQ·min or TR < 3.0).

There were significant differences in bread-making performances among these cultivars. The baking water abs at 14% mb were 64.2±1.1%. All cultivars including checks had higher water abs (≥ 62.0%). The mixing times (MT) were 5.1±1.2 min. All cultivars including checks had normal MT (3.0 -7.5 min). The dough handling rates were 3.9±0.4. The loaf volumes (LV) and specific volumes (SV) were 1012±42 cc and 7.3±0.3 cc/g, respectively. All cultivars including checks had LV > 850 cc or SV > 6.5 cc/g. After stored overnight, the breadcrumb firmness was 2787±485 Pa. The crumb brightness and non-uniformity were 147±5 and 6.3±3.7, respectively. The cell number, diameter, and elongation were 7036±256, 2.0±0.1 and 1.5±0.0, respectively. Most cultivars had good crumb texture and structure. The overall bread scores were 4.6±0.4. All cultivars including checks were scored as having fair or better bread quality.

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

The 2015 data are:

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

The data for 2014 are:

2014	Mead	Linc.	ClayCen	McCook	Nplatte	Sidney	Alliance	**Average**		Average	Average	Average	Average	Average
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	**Yield**	**Rank**	Testwt	Height	Hdate	WintSurv	BacStreak
name	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	**bu/a**						
WESLEY	25.7	70.0	51.5	87.6	58.3	56.2	66.9	**59.5**	**41**	60.2	30.8	148.4	100	5.7
OVERLAND	34.1	71.9	60.7	82.8	56.9	70.8	68.3	**63.6**	**16**	61.2	33.8	148.4	100	3.4
NE01481	26.7	68.3	49.0	87.2	56.4	73.8	50.5	**58.8**	**49**	61.1	33.5	148.0	100	5.9
NI04420	33.0	71.2	53.1	83.0	53.8	74.3	70.2	**62.7**	**20**	61.9	31.7	148.3	95	5.5
NE06430	31.4	72.1	47.5	82.5	54.6	64.0	59.6	**58.8**	**50**	61.0	32.2	147.7	98	6.2
NE06545	30.9	72.6	56.4	70.6	51.6	74.5	72.2	**61.3**	**30**	59.8	30.8	147.9	94	3.9
NE07486	33.2	73.9	50.8	81.4	49.5	70.4	62.8	**60.3**	**34**	61.1	31.4	147.5	100	4.4
NE07531	27.9	74.7	52.9	81.5	52.2	72.5	68.9	**61.5**	**27**	60.3	32.4	148.0	100	6.0
NE08499	34.7	72.7	56.9	80.4	45.4	66.9	61.2	**59.7**	**39**	60.5	32.4	147.7	95	3.8
NE09517	33.5	72.7	59.2	86.3	54.9	79.5	67.3	**64.8**	**8**	61.6	32.9	148.2	100	5.6
NE09521	31.9	69.4	55.0	80.5	55.1	71.3	57.9	**60.2**	**37**	60.8	34.0	148.1	89	5.6
NE10478	30.8	79.1	52.6	87.5	54.2	62.6	56.4	**60.5**	**32**	61.0	29.5	148.0	97	6.2
NE10507	34.1	76.2	53.4	87.8	56.9	77.2	52.7	**62.6**	**21**	59.7	32.8	148.0	98	4.9
NE10589	26.2	77.9	63.5	85.6	54.5	77.7	71.8	**65.3**	**4**	60.9	32.1	148.3	94	5.4
NE10683	35.6	73.2	59.5	91.9	60.5	73.0	61.9	**65.1**	**7**	58.3	33.4	148.7	100	5.5
NH11489	31.2	78.7	56.2	90.5	61.4	76.9	62.1	**65.3**	**5**	61.9	31.5	147.7	98	5.5
NH11490	31.3	79.1	62.9	91.9	57.0	70.3	65.1	**65.4**	**3**	61.8	29.9	147.3	100	5.8
NHH11569	43.9	77.9	68.4	86.2	56.5	77.0	64.7	**67.8**	**1**	60.7	33.3	147.7	97	3.2
NI09710H	21.9	70.1	45.6	89.9	62.1	61.7	64.3	**59.4**	**42**	58.7	31.0	150.1	100	6.5
NW03666	32.5	67.9	54.3	86.3	53.1	69.8	53.7	**59.7**	**40**	61.0	33.3	148.9	84	3.9
NW07505	36.9	73.8	58.0	94.1	53.7	72.8	61.2	**64.4**	**12**	60.5	32.9	148.1	92	4.9
NW09627	33.3	68.3	48.7	76.2	47.3	72.1	68.6	**59.2**	**46**	60.5	31.3	147.2	97	5.4
NW11511	29.3	69.6	51.3	85.6	58.0	68.2	71.7	**62.0**	**26**	59.5	30.8	149.2	88	5.7
NI12702W	30.2	73.0	58.6	84.0	57.0	68.3	67.1	**62.6**	**23**	62.6	32.1	148.4	91	3.8
NI12709	31.2	77.0	57.6	89.5	56.3	70.3	60.1	**63.1**	**17**	61.7	31.6	147.8	100	5.0
NI13703	30.3	67.6	48.3	92.3	54.9	64.1	55.7	**59.0**	**48**	62.2	31.2	146.1	95	5.7
NI13706	36.9	75.1	56.3	97.3	55.0	81.3	64.9	**66.7**	**2**	61.5	30.5	147.6	100	6.2
NI13708	32.8	67.6	50.6	88.4	57.1	69.6	54.3	**60.1**	**38**	61.5	29.1	147.8	100	6.8
Camelot	35.3	75.7	58.7	83.6	51.6	76.5	68.1	**64.2**	**13**	61.1	34.5	149.9	97	4.4
NI04421	28.3	69.4	56.2	95.4	59.6	78.5	58.3	**63.7**	**15**	60.8	32.2	148.8	98	5.8
Settler CL	25.9	69.3	46.6	90.0	57.9	70.5	54.8	**59.3**	**45**	61.4	30.9	148.8	100	5.8
NI13717	24.8	70.6	47.9	84.2	56.8	66.9	71.1	**60.3**	**33**	61.0	31.7	148.4	95	5.9
NI13720	34.2	70.8	55.5	87.9	56.9	65.0	64.2	**62.1**	**25**	60.9	28.3	148.2	100	5.5
NE12408	32.4	69.0	55.6	62.3	53.2	71.5	51.8	**56.5**	**56**	60.0	30.7	147.9	97	5.6
NE12409	26.7	58.4	39.1	76.3	47.1	61.9	58.8	**52.6**	**58**	60.8	29.9	148.8	83	5.4
NE12429	32.0	73.0	58.2	89.2	59.3	75.8	63.5	**64.4**	**11**	61.6	31.1	148.9	100	4.8
NE12430	29.3	74.0	49.4	76.6	53.6	69.1	59.7	**58.8**	**51**	61.2	30.8	148.2	89	6.4
NE12438	37.9	72.4	57.1	87.1	58.2	76.0	62.8	**64.5**	**10**	61.0	33.1	147.7	98	3.8
NE12439	40.6	72.0	57.2	83.6	58.2	75.7	69.7	**65.3**	**5**	60.7	31.7	147.0	90	3.5
NE12443	29.9	71.6	56.0	67.1	54.4	71.7	70.6	**60.2**	**35**	60.6	33.6	147.9	100	3.6
NE12444	24.7	60.1	51.0	82.0	48.0	76.7	71.8	**59.2**	**47**	62.3	31.8	148.1	97	5.3
NE12461	25.4	70.2	49.9	89.0	54.5	69.4	56.8	**59.3**	**44**	60.7	30.7	148.5	95	4.7
NE12464	21.9	68.3	47.0	81.0	59.5	74.8	68.6	**60.2**	**36**	60.4	31.6	148.0	95	5.7
NE12483V	33.2	71.4	45.3	83.3	45.5	68.9	61.5	**58.4**	**52**	61.1	30.6	147.7	95	5.6
NE12488	30.2	69.2	52.2	85.2	57.4	72.9	71.2	**62.6**	**21**	61.7	32.2	147.8	100	5.2
NE12510	22.9	73.9	59.2	81.8	30.5	55.2	51.9	**53.6**	**57**	54.4	30.0	149.0	95	4.5
NE12518	19.7	73.6	56.3	72.7	48.3	69.2	62.5	**57.5**	**54**	60.2	34.6	148.3	98	5.5
NE12524	31.3	71.2	42.5	81.2	41.5	68.6	66.1	**57.5**	**53**	60.7	31.4	149.0	100	6.7
NE12561	31.8	79.2	54.1	87.3	57.6	74.3	63.5	**64.0**	**14**	62.1	31.0	150.2	98	6.2
NE12571	26.8	75.2	57.4	95.4	48.6	72.2	63.7	**62.8**	**19**	61.3	33.5	148.5	93	5.4
NE12580	27.4	67.6	46.6	90.0	47.1	67.3	52.1	**56.9**	**55**	61.7	30.9	150.9	95	6.2
NE12589	35.3	76.7	59.0	86.6	52.5	70.4	71.5	**64.6**	**9**	61.7	31.9	149.1	94	3.5
NE12630	38.5	69.5	55.4	76.8	48.2	70.9	68.3	**61.1**	**31**	60.4	32.7	147.9	98	4.5
NE12637	27.4	67.6	60.4	84.8	54.5	72.9	70.2	**62.5**	**24**	61.3	31.7	150.4	97	2.7
NE12662	37.4	72.4	56.5	78.7	44.2	64.9	61.2	**59.3**	**43**	61.7	32.9	147.7	97	4.8
NE12686	23.9	70.2	56.9	99.6	53.4	68.7	67.3	**62.9**	**18**	60.9	30.2	148.1	95	5.9
NE05548	30.3	68.9	54.6	82.4	52.7	75.3	65.3	**61.4**	**28**	61.1	36.1	148.5	100	5.9
GOODSTREAK	39.1	74.8	50.5	84.9	46.6	73.3	60.0	**61.3**	**29**	60.4	37.3	148.1	100	3.7
SCOUT66	32.0	57.3	36.5	67.3	40.4	60.1	37.1	**47.2**	**60**	60.6	38.0	148.2	100	5.9
CHEYENNE	25.8	52.2	42.1	70.0	44.9	54.6	47.5	**48.2**	**59**	59.9	37.6	131.8	100	4.3
Mean	30.9	71.3	53.5	84.2	53.1	70.5	62.6	**60.9**		**60.8**	**32.1**	**148.0**	**96.5**	**5.1**
LSD	7.8	7.4	6.8	10.5	10.0	7.4	9.6	**8.5**						
CV	15.5	7.5	7.9	6.1	11.6	6.5	9.5	**9.2**						

Data from 2014 to 2016 (three-year average) from the Nebraska Intrastate Nursery for Grain Yield (bu/a) are presented below:

	Mead	Mead IM	Linc. IM	Lincoln	C Center	N. Platte	McCook	Grant	Sidney	Alliance	**Average**	**Rank**
	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**	
	3	1	2	3	3	3	3	2	3	3	**26**	
CHEYENNE	20.1	24.2	33.5	31.5	22.2	48.2	55.5	49.0	45.7	42.0	**38.8**	**14**
GOODSTREAK	34.3	54.2	57.2	43.6	30.2	51.9	61.6	56.5	51.6	47.7	**49.9**	**12**
PANHANDLE	25.4	58.4	51.1	42.0	28.2	53.7	65.0	59.1	56.4	53.9	**50.4**	**11**
FREEMAN	32.1	69.4	84.4	56.0	37.6	54.3	68.3	73.0	61.3	58.5	**59.9**	**4**
RUTH	33.7	77.6	87.1	60.4	49.8	55.6	67.3	72.3	59.4	56.3	**62.3**	**2**
NE12561	40.5	72.9	73.2	53.9	50.0	55.6	67.0	66.7	58.0	50.6	**59.7**	**5**
NE12589	38.6	78.1	71.2	57.5	40.7	52.6	62.9	65.2	52.7	56.1	**58.2**	**7**
ROBIDOUX	30.3	65.5	76.6	55.1	45.8	55.8	76.5	73.7	61.2	55.6	**60.5**	**3**
NI12702W	37.0	53.5	72.6	62.5	45.6	64.5	68.3	63.7	54.2	49.5	**58.6**	**6**
NI13706	38.5	84.4	82.3	55.1	44.9	60.5	72.8	68.6	58.6	55.4	**62.6**	**1**
OVERLAND	29.4	53.8	66.9	49.3	40.1	55.7	67.3	67.7	57.1	52.0	**55.0**	**8**
SCOUT66	28.6	32.8	35.1	38.4	22.4	41.6	54.8	50.2	46.1	36.5	**40.1**	**13**
Settler CL	26.3	67.3	65.6	43.9	32.2	58.2	75.5	63.5	50.7	44.5	**53.3**	**9**
WESLEY	24.6	58.2	72.1	47.6	33.3	59.1	61.6	61.1	48.9	52.3	**52.5**	**10**
Average	**31.4**	**60.7**	**66.3**	**49.8**	**37.4**	**54.8**	**66.0**	**63.6**	**54.4**	**50.8**	**54.4**	

As can be seen from the excellent three-year yields of released lines (Ruth, Robidoux, and Freeman), our new and released lines continue to do well, but we have many experimental lines with excellent grain yields in the east, central, or west parts of Nebraska. Of particular note is NI12702W, which is a high-yielding white wheat and NI13706, a new hard-red winter wheat. NE12589 has very good stem-rust resistance. As expected Cheyenne and Scout 66 were the lowest yielding lines. Both broadly and more narrowly adapted lines have value in wheat production.

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

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

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

The data for 2015 are:

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

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

The data for the 2014 TRP:

2014	Mead	Linc	Ccenter	Nplatte	McCook	Sidney	Alliance	Average	rank	Average	Average	Average
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	**Yield**	Hdate	Hegith	Testwt
name	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	**bu/a**	Julian	(in)	lbs/bu
Camelot	37.9	75.4	59.9	38.4	90.2	73.5	62.9	62.6	**11**	149.12	35.19	61.70
Freeman	28.2	70.2	52.6	48.5	82.0	63.4	67.4	58.9	**39**	148.15	32.31	61.85
GOODSTREAK	39.3	74.4	53.5	41.0	85.4	74.8	58.3	61.0	**21**	148.98	40.37	61.90
NE13402	23.8	63.4	40.5	47.8	78.5	56.5	59.4	52.8	**58**	146.15	28.49	61.20
NE13405	37.7	75.9	64.6	40.1	91.1	75.2	64.1	64.1	**4**	147.18	32.56	62.60
NE13412	31.8	56.8	42.1	35.0	81.9	61.3	52.4	51.6	**59**	147.84	34.34	62.03
NE13420	31.3	68.8	52.7	36.5	77.6	65.3	53.6	55.1	**53**	148.25	33.91	62.55
NE13425	38.3	71.1	61.1	41.9	81.9	67.9	65.5	61.1	**19**	147.54	32.56	62.38
NE13430	28.2	67.0	54.3	47.1	74.1	66.3	58.6	56.5	**50**	148.04	35.74	62.08
NE13434	54.1	74.5	64.1	46.9	85.9	74.7	63.1	66.2	**1**	148.86	33.69	62.03
NE13438	23.9	65.1	59.3	39.1	88.5	72.8	65.8	59.2	**35**	148.84	30.54	62.83
NE13443	7.2	45.5	40.9	40.1	76.4	60.5	57.9	46.9	**60**	149.20	29.39	61.85
NE13445	39.0	69.4	61.1	41.9	76.8	78.9	63.6	61.5	**16**	148.02	35.91	62.08
NW13455	46.5	68.6	62.0	41.7	89.8	74.9	59.3	63.3	**8**	148.84	34.09	62.30
NW13457	30.4	66.4	55.7	43.6	72.1	77.4	67.6	59.0	**38**	148.49	34.16	62.85
NW13458	24.4	62.1	53.2	40.9	82.2	71.7	49.6	54.9	**55**	149.26	34.51	64.30
NE13471	25.5	67.1	50.7	38.3	81.2	56.5	59.0	54.0	**57**	148.28	33.71	60.95
NW13480	28.6	64.0	53.4	42.9	78.9	68.4	66.6	57.5	**47**	149.95	31.83	60.30
NE13482	26.5	69.8	57.2	42.2	87.2	64.7	64.2	58.8	**40**	149.65	34.13	60.60
NE13483V	28.1	62.8	57.5	44.5	88.1	81.1	61.2	60.5	**26**	149.93	35.00	63.60
NE13484V	24.5	67.0	56.6	39.4	82.0	66.0	50.1	55.1	**54**	148.97	33.01	61.23
NW13491	20.1	63.7	52.4	50.1	94.5	60.7	55.8	56.8	**48**	149.86	31.07	62.58
NW13493	31.5	70.9	64.8	47.7	93.9	77.2	57.1	63.3	**7**	149.63	32.50	62.50
NW13494	32.6	64.2	60.5	44.1	90.9	69.4	60.0	60.2	**27**	148.98	32.64	62.90
NW13499	31.8	69.0	60.0	38.5	83.9	78.4	51.8	59.1	**37**	149.51	37.23	62.00
NW13502	34.9	77.2	59.5	40.5	90.1	75.3	60.2	62.5	**12**	149.40	33.90	62.08
NE13510	39.2	66.3	54.0	37.9	81.0	67.6	50.7	56.7	**49**	148.84	31.03	61.00
NE13511	26.8	74.2	61.5	51.1	87.9	78.3	59.8	62.8	**10**	150.02	32.64	62.33
NE13515	31.3	71.3	56.6	33.4	97.0	73.3	67.3	61.5	**17**	149.00	34.14	62.28
NW13516	27.4	67.7	56.6	43.9	74.7	79.2	71.0	60.1	**29**	149.65	32.61	60.68
NW13518	30.4	65.6	54.1	45.0	80.0	71.0	61.2	58.2	**44**	149.80	32.19	60.25
NW13535	29.8	67.9	55.5	42.1	82.8	65.3	49.3	56.1	**51**	149.47	32.64	62.18
NW13536	32.9	66.3	63.0	41.9	82.6	68.0	58.8	59.1	**36**	149.33	29.86	62.55
NW13542	42.3	69.6	57.9	42.3	82.4	72.9	52.6	60.0	**30**	149.77	35.24	62.98
NE13544	39.1	62.4	61.2	49.9	81.6	75.0	47.3	59.5	**34**	149.67	32.91	62.20
NE13545	23.2	75.3	64.2	43.1	80.6	75.0	55.5	59.6	**33**	150.16	35.16	62.48
NE13546	35.6	70.3	56.9	38.1	59.6	62.4	59.6	54.6	**56**	148.97	34.87	60.58
NE13550	30.8	75.4	53.9	44.8	79.3	78.6	56.3	59.9	**31**	148.13	32.91	62.60
NE13554	23.4	71.5	62.2	51.7	84.8	81.4	66.1	63.0	**9**	151.63	35.73	62.40
NW13560	36.4	68.1	56.4	42.1	78.0	74.8	70.2	60.9	**23**	150.40	32.84	60.33
NE13564	24.2	66.7	55.5	39.6	74.6	68.2	60.0	55.5	**52**	149.16	32.91	62.08
NW13570	37.4	66.5	57.2	48.7	95.6	79.0	53.0	62.5	**13**	150.00	32.46	61.28
NW13574	33.7	73.6	61.3	41.2	75.8	79.0	67.8	61.8	**14**	149.65	36.76	62.95
NE13583	31.7	66.7	58.2	39.7	91.4	74.7	61.9	60.6	**25**	149.63	31.74	61.80
NE13585	32.1	67.7	57.3	39.8	81.5	70.3	61.2	58.6	**42**	148.80	31.73	60.53
NE13589	33.0	73.2	56.0	42.0	70.6	77.2	66.9	59.8	**32**	149.70	34.87	62.38
NE13593	31.8	68.7	58.2	43.4	93.2	73.3	60.0	61.2	**18**	149.40	34.77	62.38
NW13596	33.3	74.2	58.4	41.5	78.8	75.5	58.9	60.1	**28**	150.07	34.61	60.05
NE13597	25.4	63.7	54.0	52.3	92.9	69.6	69.2	61.0	**20**	150.02	31.30	61.73
NE13604	25.5	74.2	62.3	49.1	89.5	84.5	72.6	65.4	**2**	150.85	35.40	62.33
NE13624	32.1	60.4	66.0	43.8	65.3	72.7	64.9	57.9	**45**	149.36	33.71	62.10
NE13625	51.2	82.2	70.0	40.1	83.0	77.0	53.4	65.3	**3**	147.70	33.44	62.80
NE13629	22.2	70.2	62.0	30.4	78.5	77.0	64.5	57.8	**46**	151.08	36.16	61.63
NW13647	18.1	60.8	57.6	49.0	88.0	75.9	61.6	58.7	**41**	150.22	33.00	63.78
NE13660	24.1	64.5	63.7	47.5	90.3	73.7	62.8	60.9	**22**	150.63	32.86	62.38
NW13669	28.0	67.8	57.9	54.3	89.8	85.1	64.1	63.9	**5**	151.03	34.70	61.88
NE13672	34.5	68.9	55.3	47.5	101.5	81.2	56.0	63.6	**6**	149.34	33.23	60.05
NE13681	25.1	68.5	65.1	29.2	81.0	78.5	62.1	58.5	**43**	149.38	35.24	62.70
NE13683	27.3	71.6	59.4	50.4	86.5	76.3	59.4	61.6	**15**	149.69	32.34	63.18
NE13687	17.5	56.8	60.2	52.4	94.0	78.2	65.5	60.7	**24**	152.71	32.96	61.98
Mean	**30.7**	**68.2**	**57.7**	**43.1**	**83.7**	**72.7**	**60.4**	**59.5**		**149.33**	**33.53**	**62.00**
LSD	9.7	9.5	6.9	11.1	12.0	7.3	9.4	9.4				
CV	16.2	7.2	6.2	15.8	5.9	6.2	9.6	9.6				

6. **Regional Nurseries**

In 2016, we continued to combine the Southern Regional Performance Nursery (SRPN) and the Northern Regional Performance Nursery (NRPN) into one larger nursery. These were planted at Lincoln, North Platte, Sidney, and Alliance. At Clay Center, only the SRPN was planted. To fill out the nursery, we added a few other lines mainly to compare selections out of research for scab tolerance or drought tolerance to determine if they had merit. The NRPN and SRPN data from all locations is available at: http://www.ars.usda.gov/Research/docs.htm?docid=11932. It was useful to see Kharkof and Scout 66, older wheat cultivars, continue to be very low yielding, indicating that breeding has made ongoing and continued progress.

Line	Nursery	Duplicate	Lincoln	N. Platte	Sidney	Alliance	Average	Rank	Line	Clay Center	Average	Rank
			Yield	Yield	Yield	Yield	Yield			Yield	Yield	
			bu/a	bu/a	bu/a	bu/a	bu/a			bu/a	bu/a	
Kharkof	SPRN-1	NRPN-1	18.9	54.7	45.5	35.7	38.70	90	Kharkof	14.4	33.8	38
Scout 66	SPRN-2		23.9	52.4	51.8	46.8	43.73	89	Scout 66	12.4	37.5	37
TAM107	SPRN-3		33.1	52.3	47.0	59.9	48.08	86	TAM107	18.6	42.2	36
Jagalene	SPRN-4	NRPN-4	54.4	89.5	69.7	60.5	68.53	16	Jagalene	38.4	62.5	21
OK11D25056	SPRN-5		64.8	75.4	72.6	55.1	66.98	22	OK11D25056	52.6	64.1	12
OK12621	SPRN-6		68.9	58.4	66.3	58.3	62.98	47	OK12621	60.8	62.5	20
OK118036R/W	SPRN-7		60.2	74.3	80.3	57.9	68.18	18	OK118036R/W	40.5	62.6	19
OK09915C-1	SPRN-8		55.1	79.0	49.7	48.3	58.03	68	OK11231	33.4	53.1	35
OK12DP22002-042	SPRN-9		76.6	91.5	60.3	73.9	75.58	3	OK12DP22002-042	60	72.5	1
OK13625	SPRN-10		61.4	80.1	66.5	59.0	66.75	23	OK13625	47.7	62.9	17
OK11231	SPRN-11		51.5	78.7	51.5	57.5	59.80	60	OK09915C-1	62.4	60.3	26
LCH13DH-14-91	SPRN-12		51.9	81.4	83.9	66.2	70.85	9	LCH13DH-14-91	48.8	66.4	9
LCH13DH-21-44	SPRN-13		58.6	96.4	83.3	56.4	73.68	4	LCH13DH-21-44	56.3	70.2	4
LCH13-048	SPRN-14		58.5	64.5	78.1	63.6	66.18	27	LCH13-048	41.8	61.3	23
LCI13DH-22-22	SPRN-15		52.4	78.9	81.2	60.0	68.13	19	LCI13DH-22-22	65.1	67.5	7
LCH13-032	SPRN-16		61.9	65.7	74.2	59.2	65.25	34	LCH13-032	57.8	63.8	15
NI13706	SPRN-17		61.1	86.3	63.8	69.3	70.13	10	NI13706	49	65.9	10
NW13493	SPRN-18		68.5	62.8	62.9	72.4	66.65	24	NW13493	46.7	62.7	18
NE13515	SPRN-19		71.7	79.8	73.3	59.0	70.95	8	NE13515	59.8	68.7	5
NW13570	SPRN-20		64.0	61.0	66.9	60.6	63.13	45	NW13570	57.6	62.0	22
CO11D1236	SPRN-21		44.3	67.5	62.7	76.6	62.78	48	CO11D1236	34.9	57.2	31
CO11D1397	SPRN-22		45.6	83.1	51.4	72.8	63.23	44	CO11D1397	23.2	55.2	33
CO11D1539	SPRN-23		43.2	87.7	65.6	79.6	69.03	14	CO11D1539	40.6	63.3	16
CO11D1767	SPRN-24		55.6	92.5	70.3	70.3	72.18	6	CO11D1767	44.9	66.7	8
CO12D922	SPRN-25		41.2	76.2	58.3	76.5	63.05	46	CO12D922	25.5	55.5	32
BCS-12L00004	SPRN-26		57.9	68.7	72.2	60.9	64.93	35	BCS-12L00004	43.2	60.6	24
KS060106-M-11	SPRN-27		65.8	78.9	71.2	41.5	64.35	40	KS060106-M-11	61.8	63.8	13
KS060143-K-2	SPRN-28		50.0	80.1	67.7	60.9	64.68	37	KS060143-K-2	44.2	60.6	24
KS061193K-2	SPRN-29		58.2	93.9	82.1	59.2	73.35	5	KS061193K-2	48	68.3	6
KS061705M-11	SPRN-30		53.8	91.7	85.1	74.6	76.30	2	KS061705M-11	46.4	70.3	3
KS080448*C-102	SPRN-31		68.9	92.7	73.0	70.8	76.35	1	KS080448*C-102	53.1	71.7	2
TX09V7446	SPRN-32		42.8	83.1	53.7	56.0	58.90	63	TX09V7446	39.9	55.1	34
TX11A001295	SPRN-33		60.3	78.6	66.7	60.9	66.63	25	TX11A001295	52.7	63.8	14
TX12M4065	SPRN-34		55.1	73.8	68.2	53.3	62.60	49	TX12M4065	49.4	60.0	27
TX12A001106	SPRN-35		48.0	78.3	73.8	64.0	66.03	29	TX12A001106	57	64.2	11
TX12A001430	SPRN-36		52.8	73.2	70.3	66.9	65.80	30	TX12A001430	35.2	59.7	29
TX12V7324	SPRN-37		61.2	60.1	68.4	58.4	62.03	52	TX12V7324	48.6	59.3	30
TX12M4068	SPRN-38		53.7	59.7	72.1	57.4	60.73	56	TX12M4068	55.9	59.8	28
Overland	NRPN-2		45.3	64.8	64.6	60.7	58.85	64				
Wesley	NRPN-3		61.8	84.6	50.1	60.7	64.30	41				
Jerry	NRPN-5		38.7	55.2	37.2	45.5	44.15	88				
LJ083 or AAC Elevate	NRPN-6		27.9	67.6	53.6	55.8	51.23	82				
LCH13NEDH-5-59	NRPN-7		55.1	76.9	55.2	63.1	62.58	50				
PSB13NEDH-14-31	NRPN-8		62.7	75.7	77.5	59.7	68.90	15				
PSB13NEDH-14-83	NRPN-9		60.4	83.4	65.2	59.3	67.08	21				
PSB13NEDH-14-71	NRPN-10		60.4	92.3	69.4	57.6	69.93	11				
LCH13NEDH-14-69	NRPN-11		51.9	95.0	68.1	61.8	69.20	13				
LCH13-056	NRPN-12		64.1	76.6	76.0	61.3	69.50	12				
NI12702W	NRPN-13		67.6	80.1	65.6	57.0	67.58	20				
NE12561	NRPN-14		58.7	73.5	64.6	61.6	64.60	38				
NE12589	NRPN-15		64.0	68.9	51.2	62.1	61.55	54				
Overland FHB-10	NRPN-16		53.2	59.2	58.6	60.0	57.75	69				
NE13425	NRPN-17		68.0	68.7	65.7	55.5	64.48	39				
NE13434	NRPN-18		56.1	63.9	68.6	67.1	63.93	42				
NE13604	NRPN-19		51.6	70.4	61.4	64.0	61.85	53				
NW13669	NRPN-20		60.6	80.2	60.5	62.9	66.05	28				
NE13672	NRPN-21		37.0	61.9	44.5	50.0	48.35	85				
NE13625	NRPN-22		49.7	62.3	44.7	61.1	54.45	79				
MTS1224	NRPN-23		45.0	56.8	67.9	58.6	57.08	72				
MT1257	NRPN-24		40.6	64.2	70.0	59.3	58.53	65				
MT1265	NRPN-25		30.2	59.8	67.3	64.1	55.35	77				
SD08200	NRPN-26		64.1	79.3	58.7	57.6	64.93	35				
SD09113	NRPN-27		37.4	81.0	49.3	55.9	55.90	76				
SD09227	NRPN-28		52.8	77.7	53.2	53.7	59.35	62				
SD10257-2	NRPN-29		43.8	84.1	63.5	57.7	62.28	51				
SD110060-7	NRPN-30		57.6	86.2	74.9	68.3	71.75	7				
SD110085-1	NRPN-31		55.2	66.0	55.1	52.5	57.20	71				
SD10W153	NRPN-32		60.7	76.3	69.3	59.1	66.35	26				
x09053_3	ABB15	15152	53.0	61.3	45.1	59.9	54.83	78				
4-19	YQV15	2017	62.8	52.5	48.2	69.3	58.20	67				
x09054_3	ABB15	15156	49.1	84.6	59.5	61.5	63.68	43				
7-11	YQV15	2007	58.6	56.2	70.0	56.0	60.20	57				
x09067_2	ABB15	15191	51.7	62.2	47.6	63.7	56.30	75				
HW_182	YQV15	2039	47.4	72.3	45.6	62.8	57.03	73				
x09141_2	ABB15	15424	30.6	61.1	49.3	47.7	47.18	87				
NE13627	YQV15	2055	54.2	58.7	61.3	65.2	59.85	59				
NE14A521	ABB15	1011	39.1	62.7	36.8	61.0	49.90	83				
11-26	YQV15	2021	42.2	66.7	59.2	65.5	58.40	66				
NE14A592	ABB15	1037	59.3	69.9	50.5	59.2	59.73	61	OVERLAND	38.1		
14-10	YQV15	2027	53.5	78.1	61.2	68.5	65.33	32	OVERLAND_FHB1_1	35.7		
NE14A598	ABB15	1095	55.0	73.0	52.2	60.5	60.18	58	OVERLAND_FHB1_10	39.1		
14-88	YQV15	2034	53.9	57.0	32.0	62.1	51.25	81	11-26	27.4		
OVERLAND_FHB1_1	RPN15		56.3	64.7	48.8	59.2	57.25	70	14-10	48.7		
N14A582	CSV15		57.2	82.5	60.3	61.3	65.33	32	14-88	55.6		
N14A593	CSV15		38.6	50.4	43.9	63.6	49.13	84	4-19	42.8		
N14A445	CSV15		40.0	91.2	67.3	63.0	65.38	31	7-11	51.1		
NW13536	YQV15	2071	47.2	79.5	54.3	64.4	61.35	55	NE15445	58.8		
N14A530	CSV15		44.0	64.0	48.1	53.9	52.50	80	NE15585	19.5		
NE15585	DUP15	x09361_9	56.8	68.3	45.8	54.5	56.35	74	NW13536	31		
NE15445	DUP15	x09021_5	57.0	77.9	76.8	61.4	68.28	17	NE13627	49.1		
CV			6.28	14.75	13.05	12.40			CV	13.52		
GRAND MEAN			**52.93**	**73.00**	**61.74**	**60.65**	**62.09**		**GRAND MEAN**	**44.51**		
LSD			7.91	20.72	15.49	14.47			LSD	9.75		
R-Square			0.97	0.86	0.84	0.81			R-Square	0.88		

7. **Multiple-Location Observation Nursery**

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

	Lincoln	Lincoln.IM	C.Center	N.Platte	McCook	Grant	Sidney	Alliance	NE. Ave.	Rank	NE. Ave. Exc. CC	Rank
	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	
Name	BLUP+Mean	BLUP+Mean	BLUP+Mean	BLUP+Mean	BLUP+Mean	BLUP+Mean	BLUP+Mean	BLUP+Mean	BLUP+Mean		BLUP+Mean	
NE16562	63.02	85.45	51.59	87.67	90.96	76.75	73.58	72.96	75.25	1	78.63	1
NE16424	62.27	91.31	47.01	73.17	84.23	77.61	77.99	73.87	73.43	2	77.21	3
NE16443	60.94	86.46	55.43	68.32	88.22	89.29	59.63	76.07	73.05	3	75.56	8
NE16402	59.04	89.66	49.60	74.60	88.79	78.51	64.47	77.18	72.73	4	76.04	5
NE16504	57.08	84.33	35.43	80.21	92.95	79.16	73.61	74.62	72.17	5	77.42	2
NE16593	57.15	85.54	44.07	72.39	86.18	77.82	70.75	79.67	71.70	6	75.64	6
NE16406	54.61	82.13	43.15	78.00	87.61	81.26	67.64	73.25	70.96	7	74.93	14
NE16412	58.05	83.56	33.34	75.91	105.38	80.96	62.49	67.14	70.86	8	76.21	4
NE16467	58.23	86.24	48.16	74.43	85.61	77.96	62.30	71.25	70.52	9	73.72	25
NE16606	56.76	86.98	43.14	76.09	81.65	77.03	62.76	78.76	70.40	10	74.29	18

The average yield of Camelot, Freeman, and Goodstreak was 63.16 bu/a and rank of 145.

8. **Early Generation Nurseries**

a. **Single-plot Observation Nursery**

Two thousand one hundred and seventy-eight lines were evaluated at Lincoln in 2016. Of the 2,178 lines and checks, approximately 1,875 were red and 303 were white seeded or mixed red and white seeded, 234 lines were two-gene herbicide tolerant lines, 76 were WSMV resistant lines, and 62 Hessian fly-tolerant lines. All 2,178 lines were harvested to get better information than through visual selection. We also did genotyping by sequencing (GBS) on all of the lines (thanks to cooperation with Dr. Jesse Poland). Due to a major hail storm severely damaging approximately one half of the nursery, we used our GBS data to help select lines that should have good grain yield and end-use quality though the plots were too badly damaged to select phenotypically. The Seed Quality Lab did an excellent job of evaluating our selections and eliminating poor quality lines before planting. Two hundred seventy lines were advanced.

b. **Headrow Nursery**

In 2015-16, 48,160 conventional and 4,800 2-gene herbicide tolerant headrows were planted at Lincoln. In general, the headrow nursery was a little larger than preferred, but suffered from hail and late heavy rains. Fourteen hundred and fifty-seven conventional lines and 202 two-gene imi-tolerant lines were selected for advancement. In addition to poor plant types, the main selection criteria for discarding headrows was poor seed quality or seed diseases.

c. **F_3 bulk hybrids**

The F_3 bulk hybrid nursery contained 884 red, red and white segregating, or white seeded bulks. In addition, most bulks were planted at Mead (our main and best winter killing site) and many of those were planted at Sidney as a backup site in case of disaster at Mead. In addition, 81 2-gene imi-tolerant bulks were planted. The number of F_3 bulks is where we wanted it. Thirty-six thousand six hundred and forty head rows were selected for fall planting in 2017. The headrows were planted on time. In general, their emergence and stands were very good in the fall. The project goal remains to have sufficiently good segregating F_3 material to select about 40-45,000 headrows so we were a little low this year.

d. **F_2 bulk hybrids**
The F_2 bulk hybrid nursery contained 1,217 bulks and check plots that were planted at Mead. Seventy-three F_2 bulks with two genes for herbicide resistance were planted at Lincoln for selection. The bulks generally survived the winter, but some were winterkilled (those involving winter tender parents). Bulks were dropped mainly for disease or lodging and 1,209 F_3 bulks were planted for selection in 2017. Note many of the 2017 F_3 bulks duplicates of the best F2 bulks, so more than eight F_2 bulks were dropped.

9. <u>Winter Triticale Nursery</u>

In 2015, it appears that NE422T had good forage potential for the southern Great Plains. We are beginning to move to higher and more consistent grain yield levels, but identifying excellent forage types requires forage harvesting which is expensive and difficult for widespread trials. Though the markets for biofuels fluctuate with the price of oil and other geologically based fuels, we believe that there is a future for triticale in a biobased energy system. Triticale can be grown over the winter as forage or grain crop in areas where maize cannot be grown successfully. The grain will substitute for maize in animal rations and the forage can be used as forage, cellulosic ethanol feed stocks, or as a ground cover.

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

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

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

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

The grain and forage data for 2015 are:

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

The 2014 grain yields from Nebraska are:

2014	Linc.	Mead	Sidney	Average	**Rank**	Bacterial	Winter	Height
	Yield	Yield	Yield	Yield		Streak	Survival	
Name	lbs/a	lbs/a	lbs/a	lbs/a		(1-9)	%	in
NT01451	3190	2368	3891	3150	**8**	3.3	100	44.1
NT05421	3641	3047	3829	3506	**1**	3.7	99	51.8
NT06422	3557	2476	3802	3278	**5**	4.5	99	48.1
NT06427	3314	1926	3742	2994	**12**	3.1	99	44.9
OVERLAND	3446	3019	3875	3447	**2**	1.8	98	36.1
NT07403	3773	2129	3481	3128	**10**	5.0	99	43.3
NT09423	3223	2663	3936	3274	**6**	2.0	100	44.6
NT10417	2291	1957	3912	2720	**22**	3.9	100	45.2
NT11406	3203	1697	3789	2896	**14**	3.0	100	44.9
NT11410	3380	1691	3440	2837	**17**	4.3	98	44.9
NT11428	3389	2399	3416	3068	**11**	3.3	100	51.5

NT12403	3258	2441	4005	3235	7	6.0	100	44.4
NT12404	3293	1868	3535	2899	13	6.1	100	43.9
NT12406	3155	2412	3859	3142	9	6.4	99	46.8
NE422T	2844	2034	3136	2671	24	4.2	100	56.9
NT12412	3008	1837	3348	2731	20	3.4	98	44.3
NT12425	3496	1956	3172	2875	15	3.0	100	51.7
NT12440	1936	1201	2910	2016	29	4.4	95	40.9
NT13403	2746	1819	3722	2762	18	5.8	99	45.4
NT13405	2259	1301	3548	2369	28	5.1	97	46.4
NT13410	2775	1812	3506	2698	23	6.3	99	47.5
NT13411	2305	1352	3563	2407	27	5.1	97	45.2
NT13412	1232	1195	3487	1971	31	4.7	91	44.5
NT13416	3444	2579	3977	3333	4	5.8	100	49.2
NE426GT	2588	2195	3499	2761	19	5.7	99	44.7
NT13420	2794	2051	3341	2729	21	6.8	99	44.7
NT13421	1817	1256	2909	1994	30	5.1	98	38.9
NT13429	2250	1720	3790	2587	26	4.8	99	47.9
NT13430	2514	1835	3627	2659	25	3.9	100	42.9
NT13443	4053	2761	3473	3429	3	3.4	99	56.3
GRAND MEAN	**2939**	**2033**	**3584**	**2852**	**16**	**4**	**99**	**46**
LSD	464	510	479			2		
CV	10	15	8			23		

The 2014 forage yields from Nebraska (thanks to Dr. Rob Mitchell, USDA-ARS) are:

entry	name	winsur	hdatejulia	height	yldlbsa	Rank	dmpercent	nitrogen	ivdmd	ndf	adf	adl
		%	After 12/31	in	lbs/a		%	%	%	%	%	%
1	NT01451	100	151	41.9	5645	9	26.8	1.92	71.33	61.07	34.95	5.13
2	NT05421	100	150	46.8	5587	11	29.3	1.67	69.11	62.02	36.19	5.35
3	NT06422	100	148	46.2	5489	15	29.9	1.80	71.53	58.58	33.63	5.01
4	NT06427	100	150	44.0	5985	6	28.4	1.75	70.10	60.32	35.00	5.15
5	OVERLAND	100	147	36.0	6059	5	29.0	1.90	71.53	60.46	34.51	5.09
6	NT07403	90	147	41.0	4896	21	31.2	1.68	69.81	60.15	34.72	5.05
7	NT09423	100	151	41.5	6569	2	27.0	1.86	70.80	61.10	35.16	5.24
8	NT10417	100	152	41.2	5189	18	26.6	1.87	71.11	61.68	35.38	5.19
9	NT11406	100	152	42.0	5348	16	28.2	1.71	70.69	59.70	34.51	5.02
10	NT11410	100	149	41.1	5598	10	28.2	1.79	70.91	59.74	34.44	5.14
11	NT11428	100	151	48.9	6244	3	27.8	1.75	70.77	61.73	35.46	5.14
12	NT12403	100	148	42.7	4964	19	29.5	1.73	69.61	59.85	34.89	5.10
13	NT12404	100	148	40.3	4825	22	30.8	1.59	69.23	59.20	34.45	4.96
14	NT12406	100	149	44.4	5863	8	29.3	1.87	69.74	59.22	34.08	5.17
15	NE422T	100	151	54.0	6241	4	27.3	1.74	69.29	63.44	37.04	5.19
16	NT12412	100	150	43.1	5294	17	28.6	1.81	70.83	59.40	33.89	4.93
17	NT12425	100	150	49.4	5923	7	29.1	1.57	69.40	61.43	35.68	5.05
18	NT12440	99	150	36.6	3051	28	28.7	1.99	72.42	58.46	32.97	4.83
19	NT13403	100	148	40.1	4028	25	29.6	1.75	71.04	58.41	33.41	4.96
20	NT13405	99	149	43.0	3015	29	28.5	2.00	71.43	59.98	34.03	4.93
21	NT13410	100	151	41.3	4070	24	28.1	1.93	71.43	59.05	33.53	5.04
22	NT13411	100	148	38.3	3907	26	28.4	1.79	70.49	58.77	33.74	4.99
23	NT13412	99	153	39.3	2599	30	26.7	2.08	70.93	61.38	34.56	5.05
24	NT13416	99	148	45.6	5557	13	30.7	1.70	70.62	58.42	33.06	4.95
25	NE426GT	100	150	42.7	5530	14	28.7	1.71	70.28	60.49	34.78	5.09
26	NT13420	100	148	42.2	4908	20	28.9	1.65	69.91	60.08	34.89	4.96
27	NT13421	96	153	34.9	3107	27	26.6	2.10	71.96	60.72	34.38	5.10
28	NT13429	99	152	44.8	4440	23	25.9	1.95	71.27	62.45	35.62	5.35
29	NT13430	100	150	40.1	5571	12	27.3	1.77	70.77	59.71	34.10	5.05
30	NT13443	100	150	54.4	7069	1	31.4	1.55	69.59	61.36	35.66	5.18
	MEAN	99.3	149.78	42.9	5086		28.6	1.80	70.60	60.28	34.62	5.08
	LSD	5.5	1.3	2.5	917		1.6	0.22	1.79	1.87	1.47	0.21
	CV	3.9	0.62	4.2	13		3.879	8.75	1.80	2.19	3.02	2.99

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

Name	Forage Yield lbs/a	Height 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 2016 Forage data from western NE (thanks to Dr. Dipak Santra) are:

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

The forage results from New York in 2014 are:

Year	Line	stage	% Dry Matter	DM T/A
2014	NE422T	early 10	13.60%	4.86
2014	NT01451	late 9	14.70%	4.87
2014	NT05421	9	13.40%	4.26
2014	NT09423	early 10	14.60%	4.99

The 2014 forage data from Sidney NE (thanks to Dr. Dipak Santra) are:

Name	Forage dry lbs/a Dry	Rank
NE422T	5920	2
NT06427	5594	4
NT01451	5030	5
NT05421	6325	1
NT07403	4844	8
NT12403	4693	9
NT06422	5631	3
NT11406	3696	10
NT11428	4884	7
NE426GT	4964	6
MEAN	5158	
LSD	1049	
CV	16.89	

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

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

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

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

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

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

To determine the effect of fungal plant pathogens on grain yield in eastern NE, we initiated a study in 2015 to compare fungicide treated and untreated plots using our elite nursery. While it is well documented that diseases reduce grain yield and fungicide use is becoming more common, growers still debate the cost and value of using fungicides. The purpose of this experiment was to provide growers with information on the value of fungicides so they can make informed decisions and also learn about our advanced breeding lines and how they respond to fungicides in the presence of disease. The Nebraska elite nursery contains 60 lines (two historic check cultivars, six cultivars, and 52 unreleased elite lines). Two fungicide regimens, treated vs. untreated, were utilized. In the treated plots, Cruiser Max® was used to treat the seed before planting. Then at early spring green-up, the plots were sprayed with Priaxor®. At flag leaf, the plots were sprayed with Twinline® followed by Caramba® at flowering. Seed treatments and fungicides were not applied to the untreated plots. Each fungicide treatment (treated and untreated) had 60 genotypes replicated twice in an alpha lattice design with an incomplete block size of five entries. Grain yield was harvested using a small plot combine and the grain was weighed after drying in the seed house. Eastern Nebraska receives on average 65 to 75 cm of rainfall annually. In 2015, the Lincoln research station received 42 cm of precipitation from 1 May to 15 June. The average flowering date for winter wheat in our elite trial was 24 May with a range from 20 May to 29 May. Hence, the conditions were ideal for Fusarium head blight (FHB, incited by *Fusarium graminearum*.). The other major disease present was stripe rust (incited by *Puccinia striiformis* f. sp. *tritici*). Other diseases that are favored by cool moist conditions were present, but not to the extent of FHB and stripe rust. Average FHB index in the untreated plots was 56% (range 4% to 96%) compared to 10% in the treated plots (an 82% reduction in index; range 0% to 68%). Yield in the treated plots averaged 3,460 kg/ha (range 4860 kg/ha to 1360 kg/ha) compared to 1,940 kg/ha (a 44% reduction in yield; range 3,500 kg/ha to 340 kg/ha). On average, the diseases caused a 44% reduction in yield (excluding the two historic check cultivars which actually yielded higher in the untreated plots; yield loss due to disease ranged from 15% to 86%). There was a significant negative correlation between FHB index and yield in the untreated plots (R = -0.38; P = 0.0034) indicating that some lines had good FHB resistance whereas others were susceptible. In contrast, there was no correlation between FHB index and yield in the treated plots (R = 0.04; P = 0.7454), indicating the effectiveness of Caramba® applied at flowering in suppressing FHB. The stripe rust reactions varied among lines from highly resistant to highly susceptible. In looking at those lines which had infection scores of 1-3 (on a 1= resistant to 9= susceptible scale) for stripe rust, the grain yield loss averaged 30% presumably due to FHB. In looking at those lines with infection scores of 7-9 for stripe rust, the grain yield loss averaged 50%. In both the resistant and susceptible to stripe rust groups, lines varied in their response to FHB with the best lines having only a 15% or 27% yield loss, respectively. Though not measured, the effects on grain volume weight and seed germination were obvious in preparing and planting seed this fall. This experiment will be repeated to provide multi-year disease loss information and to ensure having high quality seed for planting. Growers in eastern Nebraska were warned of the scab epidemic and many decided to use fungicides despite the low price of wheat. Clearly this year fungicides were economically beneficial, especially when coupled with cultivars that also had some tolerance or resistance to FHB and stripe rust.

In the second year 2015-2016 growing season, NIN trail was planted at Mead research station in addition to Lincoln research station. Stripe rust, leaf rust and Septoria tritici blotch were predominate diseases observed in non-fungicide treated NIN trials in Lincoln and Mead research stations. Other fungal diseases included tan spot and spot blotch with minor effect on wheat grain yield due to large scale presence of leaf rust and stripe rust. The two-research sites saw above average rainfall in the month of May that created conducive environmental conditions for occurrence of fungal diseases. Although the rainfall coincided with the flowering period of NIN trials in Lincoln and Mead, fusarium head blight was not observed in the field. The crop losses due to fungal diseases were 36% and 26% at Lincoln and Mead respectively. Stripe rust caused 22% crop loss and septoria blotch account for 9% crop loss in Lincoln. Crop loss of 24% caused by leaf rust in Mead. The overall correlation between disease severity in Lincoln and Mead was (0.53). There was a negative correlation between grain yield and disease severity at (0.55) in the two locations. The correlation between grain and yield was (-0.45) at Mead and at Lincoln the correlation was (-0.38). This indicates that fungal diseases were the major cause of yield reduction at both locations. Fungicide application demonstrated to be very effective in preventing on average 31% crop losses (1,495 kg/ha) in two sites. This is the second consecutive year in a row that fungal diseases cause a large portion of crop losses in NIN non-fungicide treated trials. However, fungicide application has proved highly effective in reducing fungal diseases effects. These effects include reduction in grain yield, reduction in wheat quality and production of mycotoxin deoxynivalenol (DON) in grain that represents a health threat to human and livestock.

12. <u>Fusarium Headblight (FHB) Breeding Research:</u> S.N. Wegulo, G. Bai, P.S. Baenziger

In previous research, we found *Fhb1*, a major gene for scab (syn. Fusaium head blight) tolerance, was not pleiotropic or linked to genes that reduce grain yield. We are using high yielding *Fhb1* lines from segregating populations and Wesley *Fhb1 or* Overland *Fhb1* in our crossing block. For the first time, we are seeing lines in our <u>multiple-location observation nurser</u>y 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. We wish to thank the **U.S. Wheat and Barley Scab Initiative** for funding to evaluate our lines for scab tolerance.

13. <u>Selecting and Suppressing Triticale Cultivars for Organic No-till Rotations in Nebraska:</u> R. Little, P.S. Baenziger

Due to funding constraints, our organic research now emphasizes selecting triticale cultivar for organic no-till rotations. The need for this research is that tilling soil reduces organic matter and can increase soil erosion. No-till organic rotations often involve crimping a cover crop and then seeding your organic crop of interest. In this research we were interested in determine if triticale genotypes differed in their ability to be crimped prior to the land being planted to soybeans. NT15471 performed well in this rotation, but additional data will need to be collected. Additional information on mulch cropping research can be found at: http://agronomy.unl.edu/farming-systems/mulch-cropping.

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

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

Four grain samples from 'Wesley' were milled into sixteen mill fractions (12 flour fractions, 4 bran fractions) according to AACC methods. Mineral concentration (As, B, Ca, Cd, Co, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Ti, Rb, S, Sr, Zn) of the whole grain and mill fractions were measured using ICP-MS. Cadmium concentration in the straight grade flour averaged 0.211 mg kg^{-1}, more than twice the EC regulatory limit (0.1 mg kg^{-1}). Cadmium concentration in flour was 30% of the concentration in the bran fraction, comprised of bran and break shorts, which are derived from the aleurone, pericarp, testa, and embryo. In contrast, Fe concentration in straight grade flour was only 8% of the concentration in bran, and Zn concentration in straight grade flour was only 13% of the concentration in bran. Cadmium concentration in the lowest ash flour streams is high, relative to Zn and Fe concentrations, which were higher in bran streams. Hence, a substantial proportion of the Cd in grain is stored in the central endosperm from which the lowest flour ash streams originate. Of the Cd recovered in milling, 50.3% was recovered in the 12 flour streams, whereas only 21.7% of the Fe recovered in milling was recovered in the 12 flour streams, and only 31.0% of the Zn recovered in milling was recovered in the 12 flour streams.

Four wheat genotypes (two high-Cd genotypes and two low-Cd genotypes) were grown in Mead, NE in 2015 (fungicide-untreated) and 2016 (fungicide-treated and –untreated). Mineral concentration and content in tissues, including terminal node, flag leaf, peduncle, rachis and seeds were monitored separately for each genotype during grain filling. From 2 weeks after anthesis (WAA) to 4 WAA, grain Cd concentration in high-Cd genotypes increased from 56% higher to 98% higher than that in low-Cd genotypes. The grain Cd concentration in high-Cd genotypes reached a plateau at 4WAA, but the grain Cd concentration in low-Cd genotypes increased until harvest. So, we think the difference in grain Cd concentration between high and low Cd genotypes was formed within the 28 days after anthesis. While the Cd content decreased in other above-terminal node tissues from 3 to 4 WAA, the Cd content in grain did not. This means that either Cd in grain cannot be remobilized to other tissues, or the Cd transported in grain were balanced with the Cd that transported out of the grain. After Cd was transported into terminal node, high-Cd genotypes transported higher percentage of Cd into spikes compared to low-Cd genotypes, while low-Cd genotypes retained higher percentage of Cd in flag leaf and peduncle compared to high-Cd genotypes.

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

In our study, grain Cd concentration was negatively correlated with grain Ca concentration, but is not correlated with grain Zn and Fe concentration, hence you can select from low Cd without affecting the beneficial nutrients of Zn and Fe.

From 2014 to 2016, we built a $F_{3:6}$ population from the F_3 population of Wesley x Panhandle by single seed decent. Each population have 30 lines. We selected 10 high-Cd lines and 10 low-Cd lines from each population using 7 KASP markers associated with low-Cd trait. The KASP markers we used are BS00065936_51, Kukri_c29560_455, wsnp_Ex_c13258_20911706, wsnp_Ex_c18107_26909127, wsnp_Ex_c2702_5013188, wsnp_Ku_c20011_29589089, wsnp_Ra_c12183_19587379. The selected high- and low-Cd lines were bulked and named as genotypic high and low bulk, respectively. We also selected 10 high-Cd lines and 10 low-Cd lines from each population through hydroponic study. Plants were grown in hydroponic system with 10 µM Cd supply for two weeks. Then, their shoot Cd concentration was measured and ranked. The top lines were selected as high-Cd lines and the bottom 10 lines were selected as low-Cd lines. The selected high- and low-Cd lines were bulked and named as phenotypic high and low bulk, respectively. For each population, the genotypic and phenotypic high- and low-Cd bulks, along with non-selected bulk (all lines bulked), each individual lines, and five checks (Panhandle, Wesley, Freeman, Overland and Ruth) were grown at Mead and Lincoln with two replications in the growing season of 2016-2017. We will assess the selection efficiency by comparing the average grain Cd concentration in genotypic and phenotypic high and low bulks and non-selected bulks, in 2017.

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

One of the great opportunities and challenges for wheat improvement is the development of hybrid wheat. Currently numerous companies have hybrid wheat breeding efforts with Saaten-Union Recherche being one of a few companies that markets hybrid wheat. Our belief is that the public sector needs to have a public, transparent hybrid wheat breeding effort to advance the science and educate the next generation of plant breeders. We have been working on hybrid wheat for the past 5 years. As of January 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 will be the lead institution and will work closely with Texas A & M University, Kansas State University, Saaten-Union Recherche in France, the Leibniz

Institute of Plant Genetics and Crop Plant Research in Germany led by Jochen Reif, and the University of Hohenheim in Germany led by Friedrich Longin. This grant is for 3-years and will support additional testing of hybrids as well as fund research into some of the key questions regarding hybrid wheat production.

Three systems by which to produce hybrid seed have been proposed in the literature. The first is through use of cytoplasmic male sterility (CMS) in a similar manner as the A-, B-, and R-Line system used in generation of hybrid sorghum. Wheat lines with a *Triticum timopheevi* Zhuk. cytoplasm are often used for the A-line and produce stable cytoplasmic male sterility. CMS presents a challenge, however, in that A- and B-lines must be developed and maintained prior to and during any large-scale production of hybrid seed. The second method of seed production is through use of thermo- or photoperiod-sensitivity genetic male sterility, a process that comes with a number of considerations for the logistics of managing and maintaining seed quality. The third involves the chemical emasculation of female parents through use of chemical hybridization agents (CHAs) — also referred to as gametocides. The use of CHAs has limitations in that the window of application is small and requires careful calibration and application for highest efficacy, but provides a simple approach and is conducive for large-scale production of experimental hybrid seed.

To develop experimental hybrids, crossing blocks were planted in the fall of 2014 and 2015. These were treated with a CHA (thanks to a collaboration with Saaten-Union Recherche) in the subsequent spring seasons to develop 650 experimental hybrids in each year. To measure CHA-induced sterility, we visually assessed gaping heads (routinely seen in genetic and cytoplasmic male sterility) and phytotoxicity, induced male sterility using bagged heads, and then harvested yield. We observed adequate levels of sterility in both years. Further statistical analysis into these data is underway. Phytotoxicity appears to be higher in the Nebraska germplasm than in the Texas germplasm. We believe this was most likely due to differences in growth and maturation rates of the two sets of germplasm post-CHA application. The Nebraska and Texas lines were very similar in immature head length in the early spring when we sprayed; thus, we sprayed all of the lines in the female block on the same day. However, the Nebraska lines flowered three days later than the Texas lines, indicating we may have sprayed the NE lines too early. That phytotoxicity with the CHA was low in the Texas material, which indicated that when CHA is properly applied, we see low incidence and severity of phytotoxicity. In the crossing block for the 2015/16 season, staging was adjusted accordingly but some differences were still observed. Anther extrusion, how well anthers are shed out of the florets, scores were important in the crossing blocks where the male lines averaged values of four to eight, with nine indicating a line with excellent anther extrusion. The correlation between harvested grain yield and anther extrusion in the male pollinator line was $r=0.59$, $P < 0.01$). The average grain yield on the female plots pollinated by Freeman, one of our best anther extruding lines (anther extrusion score: eight), was 768 g/plot. The seed set on the female lines pollinated by Freeman was also helped in that Freeman is a moderately late line; thus, the maximum amount of pollen would be shed while the female lines were "gaping" indicating a proper nick for the parents to produce hybrid seed. The correlation between anther extrusion and seed weight was not significant in the 2015/16 growing season. This result was thought to be due to phytotoxicity of the CHA with some lines delayed up to ten days compared to the untreated parent. A CHA optimization study has been planted for 2016/17 to optimize the chemical for Nebraska growing conditions.

The 650 hybrids were planted in 2015 at Lincoln, North Platte, and Alliance in Nebraska to evaluate hybrid performance across the different climate zones of the state. A fourth hybrid yield trial was planted in McGregor, TX in collaboration with Drs. Jackie Rudd and Amir Ibrahim. The yield of these experimental hybrids is being compared against three standard commercial checks, as well as to the parents of the crosses for estimates of mid- and high-parent heterosis. Initial evaluation of the trials showed excellent purity of nearly all hybrids and ratings for performance have been noted throughout the growing season. An additional year of hybrid testing was planted in 2016 and will be evaluated during the 2017 season for the same traits. A specialized field trial design was incorporated in both years of the hybrid yield trials allowing for spatial correction modeling and appropriate statistical inference. The initial results from the 2016 yield trial indicate that this design captures the spatial variation of the fields being used and is appropriate for continued use in future. These hybrids will also be used to build predictive models for the development of heterotic pools and screening of potential future hybrids.

Production costs must be controlled if hybrid wheat will be a viable option for growers in the near future. The major problem in production is the floral architecture, specifically male characteristics, of wheat. In 2014 and 2015, a total of 290 diverse lines from across the Great Plains were rated for anther extrusion on a 1 to 9 scale with 9 indicating excellent extrusion. The results showed that many Nebraska lines were good to excellent for anther extrusion with Freeman as an example of excellent. Other lines were very poor for anther extrusion with Camelot being a line which extrudes almost no anthers. The next object for this research will be to evaluate a Camelot x Freeman doubled haploid population starting in 2018 and evaluate the hard winter wheat association mapping panel in 2016, 2017, and 2018 for anther extrusion, anther length, pollen mass, and flowering duration with the idea that we can identify markers which could aid in selection for better male parent characteristics and give an idea of the genetics behind male floral characteristics.

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

Drought globally is the most widespread limitation to wheat productivity and stability in rainfed systems. The Great Plains wheat belt has been battling drought for years. Consequently developing wheat cultivars with enhanced drought tolerance and high yield has been the focus of many wheat improvement programs. Improving drought tolerance is challenging due to its complex nature and previous studies conducted in identifying key genes/quantitative trait loci (QTL) were based mostly on low-density markers and not able to provide precise information about the numbers and locations of QTLs controlling the traits related to drought. To increase the power and precision of QTL mapping in wheat, the need is to develop high-density linkage maps. Genotyping-by-sequencing (GBS) is one of the next generation sequencing methods that allows sequencing, discovery and genotyping of thousands of SNPs in cost effective manner and quickly. The SNPs generated through GBS can be used to develop the high-density linkage maps for precision QTL mapping in wheat. High-density linkage maps may be useful to genetically dissect and find the key genes underlying complex traits like grain yield in wheat. The present project was undertaken with following objectives to (i) determine genetic variability of the recombinant inbred lines (RILs) derived from contrasting parents Harry x Wesley for several morpho-physiological traits under multiple rainfed environments (ii) develop high-density linkage map based on GBS generated SNPs in 204 recombinant inbred lines (RILs) (iii) determine the reliability of the newly constructed map with known tagged genes of chaff color and wax/ glaucousness, and (iii) identify QTLs and QTL x environment interaction for several morpho-physiological traits. After stringent filtering, a high-density linkage map was constructed with 3641 SNPs distributed on 21 linkage groups. The total length of linkage map spanned 1959.34 cM with an average distance of 2.59 cM between adjacent markers. The high accuracy and reliability of this map were illustrated by finding and co-localizing the genes for chaff color and wax/glaucousness to correct and previously mapped genomic regions. A total of 67 additive QTL associated with grain yield, yield-related traits, and plant height were detected across 14 environments. These QTL were distributed across 17 chromosomes (1A, 1B, 2A, 2B, 2D, 3A, 3B, 4A, 4B, 4D, 5A, 5B, 6A, 6B, 7A, 7B and 7D). A maximum number of 8 QTL were found on 3A and 7B chromosomes and minimum of 1 QTL on 4D. For all traits, the highest number of 33 QTL were detected on B genome, 25 on A genome and 10 on D genome. Among all the QTL, 40 (59%) loci involved alleles from Harry for increasing phenotypic values, whereas the other 27 (31%) loci had alleles from Wesley for decreasing phenotypic values. This indicated that favorable alleles for all the traits were distributed between both the parents. Major and stable QTL were found for grain yield on 6B and 3A chromosome, for thousand grain weight on 2B, heading date on 5A and flag leaf length and width on 5A and 7A. For plant height, a major QTL *qph.hw.2D* was found in all the 14 environments and height reducing allele for this QTL was contributed by Wesley parent. Digenetic interactions between QTLs was evident for all the traits, however, none of the interactions were stable across locations. QTL x environment interactions were also evident for all the traits, however, grain yield and yield-component traits revealed more interacting QTLs with environment than the plant height, thousand-grain weight and heading date.

17. Translating genomic research into cultivar development in the Nebraska wheat program: Vikas Belamkar, Mary J. Guttieri, Ibrahim El-basyoni, Waseem Hussain, Diego Jarquín, Nicholas Garst, MengYuan Wang, Amanda Easterly, Jesse Poland, Aaron Lorenz, P. Stephen Baenziger

Summary of 2016:

Bioinformatics, statistics and quantitative genetics analyses for selections, advancements and parental selections in the small grains breeding program: We built a new SNP calling pipeline using the revamped version of the software TASSEL 5v2. Processed genotyping-by-sequencing (GBS) data of ~14,000 samples, ~5,500 unique lines and identified over 128,000 SNPs. Analyzed phenotype data of the $F_{3:5}$ nursery containing ~1,800 lines grown in one environment, and $F_{3:6}$ nursery with 270 lines grown in 10 environments. Performed marker-trait analyses including genome-wide association analysis (GWAS) and genomic selection (GS), and assisted with selections and advancements. The $F_{3:5}$ nursery was hit by a hail storm and phenotype data of nearly half the nursery (~1,000 lines) was damaged. GS recovered lines from this set and they were advanced. For the first time, GS was used to make selections in the 2016 $F_{3:6}$ nursery. Lastly, nearly 10-15 lines with exceptional genetics from the $F_{3:6}$ nursery grown in 2012-2016 were retrieved and included in the 2017 greenhouse crossing block. Overall, there has been significant integration of genomics in the UNL wheat-breeding program.

Details:

Each year breeding lines are selected and advanced using a “breeder’s selection palette”, which is comprised of key phenotypic traits. Phenotype-based selections (PBSs) can be affected by biotic and abiotic stresses, and unforeseen changes in weather such as excess rain or damage due to hail. Further, PBS fails to capture the ability of a line to perform well in multiple growing-years under varied environmental conditions. Augmenting selection-palette with genomic information can aid in making better selections and overcome above limitations.

We have used genomic-assisted breeding tools, genomic selection (GS) and marker-assisted selection (MAS) during early and intermediate phases of testing in a breeding program to mitigate the challenge of extreme weather events during a growing season that can reduce phenotypic selection accuracy and impede breeding progress. The datasets used in this study comprise three nurseries, $F_{3:5}$

(2015-2016; ~4,000 lines; tested at 1 location), $F_{3:6}$ (2012-2016; 1,340 lines; 8-10 locations) and $F_{3:7}$ (2013-2016; 228 lines; 6-9 locations) that represent early, intermediate and advanced testing stages, respectively. Genotyping-by-sequencing (GBS) provided ~100,000 high-quality SNPs for GS and MAS efforts. MAS was performed by identifying GBS-derived SNPs in strong linkage disequilibrium with markers tagging known loci for disease resistance, height and grain quality. This was critical in 2015 when grain quality could not be measured due to heavy rain and disease after flowering. Genomic selection for yield was performed using 10-fold cross validations for each of the years, and the prediction abilities ranged from ~0.20 to ~0.50. Prediction ability for an entire new trial ranged from 0.154 to 0.376.

In summary, GS and MAS have supplemented the "breeder's eye." We found that using GS in early and intermediate stages to predict grain yield (1) made selections more precise by using the variation from multiple growing-years under different environmental conditions; (2) identified elite lines sooner for crossing; (3) selected best lines after a hail event destroyed half of the single location $F_{3:5}$ trial grown in 2016; and (4) identified locations resulting in higher or lower predictive ability. Performance of lines advanced from $F_{3:6}$ to $F_{3:7}$ indicated GS would have outperformed phenotypic selection during two extreme weather years and emerged ~50% successful in a normal year. GS and MAS have increased selection accuracy and accelerated cultivar development in challenging weather conditions. We're one of the few public breeding programs to have successfully used GS for cultivar development.

18. Broadening the Genetic Base of Wheat Using Primary Synthetic Wheat: Madhav Bhatta, P. Stephen Baenziger, and Alexey Morgounov (CIMMYT-Turkey)

Wheat (*T. aestivum* L.) improvement from intercrosses of existing elite materials has narrowed the genetic diversity of the crop resulting in a slower genetic gain. The potential use of synthetic hexaploid wheat to enhance breeding outcomes is well known. However, the success of synthetic hexaploid wheat utilization in breeding could have been much higher if they were guided by the knowledge of genes controlling biotic (diseases) and abiotic (drought) stresses. The main goal of this research was to identify superior primary synthetics possessing resistance to diseases, and drought, identify the respective genes and develop molecular markers that can be used for marker assisted transfer of the genes in to high yielding modern wheat germplasm, and evaluate variations for grain quality and mineral content. Primary synthetic hexaploid wheat (126) developed by CIMMYT and Kyoto University (Japan) was used to assess the genetic diversity for biotic and abiotic stresses. First year phenotypic data showed resistance to cereal cyst nematode (17 entries), common bunt (46), stem rust (25), leaf rust (80), stripe rust (13), and barley yellow dwarf virus (15). A number of these synthetics showed higher grain yield (44 entries) and grain protein concentration (49 entries) compared to checks (Gerek and Karahan) under drought stressed environment. Furthermore, these synthetic lines varied widely for grain mineral concentrations and could be a potential source for genetic biofortification. Thus, synthetic lines represent valuable sources for broadening the genetic base of elite wheat breeding germplasm.

19. Genome-wide association study (GWAS) and breeding for common bunt and stem rust resistance in Nebraska winter wheat Amira Mourad, Ahmed Sallam, Vikas Belamkar, Stephen Wegulo, Jesse Poland, Robert Bowden, Guihua Bai, Ezzat Mahdy, Bahy Raghib, Atif Abo El-Wafaa, Yue Jin and P. Stephen Baenziger

A. Stem rust resistance in winter Nebraska wheat:

Stem rust (caused by *Puccinia graminis* f. sp. *tritici* Eriks. & E. Henn.) is a major disease in wheat (*Triticum aesitvum* L.). However, in recent years it occurs rarely in Nebraska due to weather, the lack of inoculum, and the effective selection and gene pyramiding of resistance genes. To understand the genetic basis of stem rust resistance in Nebraska winter wheat, stem rust seedling resistance was evaluated in the DUP2015 and TRP2015 nurseries with a total number of 330 genotypes for up to fifteen stem rust races in the TRP2015 and to the Nebraska common race, QFCSC in the DUP2015 nursery. The two nurseries were genotyped for four stem rust genes (*Sr31, SrAmigo, Sr24,* and *Sr38*) at USDA-ARS. Based on the genotyping data, pedigree and the phenotyping data, the two nurseries were postulated to contain additional resistance genes; *Sr6, Sr36, SrTmp, Sr30,* and *Sr9e*. To corroborate the presence of these genes, SSR markers were used. A few genotypes contained markers for multiple stem rust resistance genes and had a very high resistance level against a wide range of stem rust races. In both nurseries, the highest percent of genotypes contained markers for *Sr6*. Genome-wide association study for stem rust resistance was done on these nurseries using 8905 SNPs and 19 SNPs on chromosome 2D (where *Sr6* was mapped) were associated with stem rust seedling resistance. High linkage disequilibrium was found among all the 19 SNPs and the SSR marker for *Sr6*. These SNPs should be helpful for marker-assisted selection for this gene.

B. Common bunt resistance in winter wheat:

Common bunt, caused by both *Tilletia caries (D.C.) Tul. (=T. tritici)* and *T. foetida (Wallr.) Liro (=T. laevis)*, could be considered as a major problem in the organic wheat fields or where seed treatments are not used. It decreases grain yield and quality. Kernels infected by this disease are usually rejected by millers as very low infection rates can result in noticeable odors in flour milled from common bunt infected wheat. In order to identify the common bunt resistance in the Nebraska winter wheat genotypes, two nurseries, DUP2015 and TRP2015 with a total number of 330 genotypes, were inoculated with Nebraska common bunt race. In addition, a set of 25 Turkish synthesis lines which were identified by CYMMIT and resistant to the common bunt race found in Turkey, were included in this study to identify the resistant lines for Nebraska common bunt race to be used in future breeding research for common bunt resistance. The tested genotypes were evaluated in two locations Mead and Lincoln with two replications each. The experimental design was replicated augmented block design with two checks, Goodstreak and Freeman. The global set of common bunt differential lines were included also to identify genes resist Nebraska common bunt race. Of the 355 genotypes, 76 had different degrees of resistance to common bunt as following; eight genotypes were very resistant with 0% infected heads, 31 genotypes were resistant with a percentage of 0.1-5% infected heads, and 37 genotypes were moderately resistant with 5.1-10% infected heads. The presence of these resistant genotypes suggests breeding for common bunt resistance in the winter Nebraska wheat nurseries should be successful. The tested Nebraska nurseries were genotyped using genotype by sequencing with a total number of 206,620 SNPs. After filtering these SNPs for minor allele frequency (MAF>0.10), maximum missing SNPs <20% and maximum missing sites per genotype <20%, a set of 6515 SNPs was used in the association analysis. The genome-wide association study (GWAS) for common bunt resistance detected 13 SNPs on chromosomes 1AL (eight SNPs), 1BL (three SNPs), 4AL (one SNP), and 6AL (one SNP) associated with the resistance. Based on the differential lines results, as well as, the location of the different Bt-genes, these significant SNPs may indicate the presence of *Bt1, Bt4, Bt5, Bt6, Bt12* resistance genes or other unknown genes in Nebraska winter wheat.

20. Winter wheat (*Triticum aestivum* L.): breeding for tolerance and recovery traits associated with drought tolerance and QTL identification at seedling stage. Ahmed Sallam, Vikas Belamker, P. Stephen Baenziger. Acknowledging the laboratory support of Waseem Hussain and Sarah Blecha.

The genetic architecture of seedling drought tolerance is complex and needs to be better understood. To address this challenge, we developed a novel protocol to test a drought tolerance in seedling winter wheat. A population of 145 recombinant inbred lines (RILs, F_9) derived from crossing between a wheat cultivar, 'Harry' (seedling drought tolerant) and 'Wesley' (seedling drought susceptible) was used to study the genetic variation for seedling drought tolerance and identify genomic regions associated with seedling drought tolerance in winter wheat. At the seedling stage, all RILs along with their parents were sown in three replications with a randomized complete block design in a greenhouse under controlled conditions. Seven traits were scored and grouped into tolerance traits (days to wilting, wilting score, and stay green) and recovery traits (days to regrowth, regrowth biomass, drought survival rate, and recovery after drought). Three selection indices were calculated (1) tolerance index, (2) recovery index, and (3) drought tolerance index (DTI). A high genetic variation was found among all genotypes for all seedling traits scored in this study. High phenotypic and genotypic correlations were found among tolerance traits as well as recovery traits. No or weak significant correlations were found between tolerance and recovery traits. The broad-sense heritability estimates ranged from 0.53 (stay green) to 0.88 (days to regrowth). Drought tolerance index (DTI) found highly significant phenotypic and genotypic correlation with all seedling traits scored in this study. Combining tolerance and recovery indices into a drought tolerance index improved selecting the best genotypes having high drought tolerance and recovery after drought period at the seedling stage. To verify this finding, we ran the same protocol on a set of 10 spring Egyptian cultivars and five US winter wheat cultivars. No significant correlation was found between tolerance and recovery traits, indicating that both types of traits may be controlled by independent genetic systems.

A genetic map and QTL mapping will be performed on the RILs population to detect genomic regions controlling both types of traits under drought stress. Furthermore, Harry and Wesley were screened for *Dreb-B1* and *1-feh w3* using Kompetitive Allele Specific PCR (KASP). The results revealed that Harry was positive for both genes, while, Wesley was negative. Therefore, all RILs will be screened for both genes to select the most promising lines having the most favorable QTL for drought tolerance and the two genes.

Genetic diversity and population structure of $F_{3:6}$ Nebraska winter wheat (*Triticum aestivum* L.) Genotypes Using Genotyping-By-Sequencing. Shamseldeen Eltaher, Ahmed Sallam, Vikas Belamkar Jesse Poland, Hamdy A. Emara, Ahmed A. Nower, Khaled F. Salem, P. Stephen Baenziger. Acknowledging the laboratory support of Waseem Hussain and Sarah Blecha.

The availability of information for genetic diversity and population structure in wheat (*T. aestivum* L.) breeding lines can help wheat breeders better understand and use their genetic resources and manage genetic variation in their breeding program. The recent advances in sequencing technology provide the opportunity to create a large number of SNPs cost effectively in large genome species (e.g. wheat). This large number of SNPs can be utilized for understanding genetic diversity and performing a genome wide association studies for complex traits. In this study, we evaluated genetic diversity and population structure in a set of 230 genotypes ($F_{3:6}$) from various crosses as a prerequisite for GWAS. Genotyping-by-sequencing provided 9,765 high-quality SNPs. The gene diversity and polymorphism information content (PIC) values across chromosome varied from 0.09 to 0.37 with an average of 0.23 The distribution of markers on the chromosomes ranged from 108 loci in the chromosome 3D to 980 loci in chromosome 2B. Three subpopulations were identified using structure software and confirmed by principal coordinate analysis (PCoA). Analysis of molecular variance (AMOVA) showed that 8% variance was among populations and 92% was within populations. The genetic similarity between sub-populations were 0.04, 0.08, and 0.10 between G1 & G2, G1 & G3, and G2 & G3, respectively. High genetic diversity among genotypes can be used to select new wheat cultivars with desirable characteristics such as high yield potential and tolerance to biotic and abiotic stress tolerance adapted to diverse environments as are found in the Great Plains.

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 that should finish qualification trials this year and begin increase for release. We continue our collaboration with Ardent Mills who support our McCook Nursery and provide valuable information on the end-use quality of our lines at that site. Southwest Nebraska is a key sourcing site for their Colorado mills. In 2010, UNL developed a collaboration with Bayer Crop Science that allows non-exclusive access to UNL germplasm and is in accordance with the principles for collaboration approved by the National Association of Wheat Growers and with the U.S. Wheat Associates Joint Biotechnology Committee. This collaboration has led to extensive collaborations and interactions on genetics, plant breeding, and crop physiology. Having their excellent staff in Lincoln has been very advantageous to student and staff interactions. In 2012, we evaluated more than 900 doubled-haploid lines created in collaboration with Limagrain and are evaluating lines in replicated trials at numerous locations. The fruits of this collaboration can best be seen in the 2016 Northern Regional Performance Nursery (below). Of the top five highest yielding lines: 1, 3, and 5 are jointly developed/owned by Limgrain and UNL. The second highest yielding line is from UNL and the fourth highest yield line is from SDSU. It should also be noted that one of the Overland lines containing the Fhb1 gene developed with USDA-ARS (in cooperation with Guihua Bai) did very well.

Table 3. Agronomic Summary of 2016 Northern Regional Performance Nursery									
		Grain Yield		Grain Volume Weight		Heading Date		Plant Height	
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Entry	Line	(kg/ha)		(kg/hl)		*(DOY)*		(cm)	
1	Kharkof	3145	32	77.2	24	157	27	110	1
2	Overland	4520	15	76.8	18	154	13	88	11
3	Wesley	4206	26	74.4	5	153	4	77	32
4	Jagalene	4577	13	78.0	28	153	7	83	23
5	Jerry	3597	31	75.1	7	157	28	94	2
6	LJ083 or AAC Elevate	4047	29	75.6	8	157	31	84	22
7	LCH13NEDH-5-59	4581	12	76.3	14	154	17	88	10
8	PSB13NEDH-14-31	4606	8	76.7	17	157	29	81	30
9	**PSB13NEDH-14-83**	**4770**	**3**	78.4	30	154	9	85	18
10	**PSB13NEDH-14-71**	**4692**	**5**	76.9	20	154	11	82	27
11	**LCH13NEDH-14-69**	**4853**	**1**	77.1	22	153	6	78	31
12	LCH13-056	4684	6	76.3	15	153	2	84	21
13	NI12702W	4425	20	79.5	32	155	20	85	19
14	NE12561	4382	21	77.4	26	154	8	82	29
15	NE12589	4311	23	77.2	25	152	1	82	26
16	Overland FHB-10	4583	11	77.1	23	154	12	89	8
17	NE13425	4627	7	78.5	31	154	15	86	15
18	NE13434	4601	9	76.2	12	154	10	87	14
19	NE13604	4584	10	76.6	16	156	23	89	9
20	**NW13669**	**4783**	**2**	76.2	11	156	22	87	13
21	NE13672	3819	30	72.6	1	154	16	82	28
22	NE13625	4048	28	78.0	29	153	3	84	20
23	MTS1224 (Loma)	4282	24	74.2	2	158	32	83	24
24	MT1257	4328	22	74.3	3	156	26	92	4
25	MT1265	4505	17	74.4	4	157	30	92	5
26	SD08200	4439	19	77.0	21	154	19	90	7
27	SD09113	4279	25	74.5	6	155	21	85	17
28	SD09227	4507	16	76.8	19	156	25	90	6
29	SD10257-2	4498	18	77.7	27	154	14	93	3
30	**SD110060-7**	**4722**	**4**	76.1	9	154	18	83	25
31	SD110085-1	4080	27	76.3	13	156	24	88	12
32	SD10W153	4556	14	76.1	10	153	5	86	16
	SAS Mean	4396		76.4		155		87	
	l.s.d. (alpha = 0.05)	229							
	MSE	316193							
	n	47							
	CV	12.8							

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

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

VII. WINTER BARLEY RESEARCH

We received our 12th year of research and development fees from an agreement with Paramount Seed Farms (a commercial seed company) for the exclusive release of our winter barley germplasm. We are fortunate that they took the initial risk of building a market for our germplasm when no one else was interested. No new barley lines were released in 2014, but P-845 (released in 2013) and two new lines are recommended for release as soon as the seed can be increased.

We had a good year for barley in Kansas and in Sidney and Mead, Nebraska. We will able to continue the nurseries and harvested sufficient seed to advance lines. We have made substantial progress in working with local brewers (which are expanding), supported growers to plant their first commercial spring malting barley field (with great advice from Drs. R. Horsley, K. Smith, and J. Wiersma) for local beer production and hope to have local craft maltsters/distillers in Nebraska in the future. We hope to replace spring malting types with winter malting types. Initially these may include lines developed in Europe that are adapted to Nebraska.

The 2016 barley data are:

Name	Colby	Mead	Sidney	Average	Rank	Anthesis	Height	Test Weight
	Yield	Yield	Yield	Yield		Date		
	lbs/a	lbs/a	lbs/a	lbs/a		D after Jan.1	in	lbs/bu
P-713	6164	3354	2585	4034	15	125.2	37.7	48.0
P-721	5766	2675	2354	3599	33	124.7	36.8	47.6
P-954	5492	3276	2398	3722	30	128.8	35.0	50.1
NB10417	5456	3027	2056	3513	35	122.7	38.3	46.5
NB10444	5741	3884	2360	3995	19	127.6	39.5	46.4
P-845	5976	3754	2494	4075	13	127.1	33.7	45.8
NB11414	5855	4168	2271	4098	12	126.2	36.9	49.3
NB11416	5797	4331	2798	4309	4	126.4	37.3	47.6
NB11430	5870	4356	2215	4147	11	123.8	38.0	49.1
NB12419	5888	3724	1963	3858	22	126.1	37.0	46.2
NB12425	6017	3917	2600	4178	8	129.0	36.5	46.1
NB12434	6419	4407	2053	4293	5	123.9	34.9	49.1
NB12437	5816	3757	2231	3935	21	129.1	35.0	47.4
NB13401	5675	3800	2659	4045	14	125.4	36.2	47.3
NB13435	6126	3093	2331	3850	24	126.6	38.0	49.0
NB14403	5950	2913	2705	3856	23	122.2	38.7	47.4
NB14404	5445	4346	2708	4166	10	124.4	36.7	47.3
NB14405	5650	3294	2342	3762	28	129.0	40.7	47.7
NB14412	6329	3785	2849	4321	3	126.0	33.5	44.6
NB14428	5764	4305	1925	3998	18	126.4	34.8	46.4
NB14429	5204	3712	2270	3729	29	125.2	35.6	48.4

NB14430	5513	4909	2542	4321	2	125.2	33.7	49.3
NB14433	5484	3833	2099	3805	26	125.0	35.2	45.7
TAMBAR 501	5876	3917	2164	3986	20	123.4	36.6	46.3
NB14422	5979	4133	2390	4167	9	125.3	33.2	44.5
NB15414	5573	3498	1603	3558	34	122.4	35.9	48.5
NB15439	5165	3766	1561	3497	37	126.1	37.1	48.1
NB15410	5681	2213	2027	3307	39	128.3	37.5	48.3
NB15420	6367	4350	2719	4479	1	123.2	36.4	48.2
NB15427	5043	3597	2437	3692	31	124.5	36.5	50.1
NB15409	5639	2391	2470	3500	36	128.8	38.1	48.3
NB15442	5902	3839	2306	4016	17	123.8	35.3	49.5
NB15412	4939	3132	1101	3057	40	123.3	37.4	49.4
NB15440	5697	3584	1641	3641	32	123.8	37.4	47.8
NB15419	5932	3251	2175	3786	27	127.8	36.9	46.1
NB15441	5947	4427	2220	4198	7	123.5	35.8	48.9
NB15417	5991	4016	2079	4029	16	124.6	36.9	49.7
NB15443	5763	3493	2211	3822	25	124.7	36.6	49.0
NB15415	6487	4098	2201	4262	6	123.8	36.2	48.5
NB15435	5283	3480	1416	3393	38	123.5	36.7	47.0
Average	**5767**	**3695**	**2238**			**125.4**	**36.5**	**47.8**

Of the released cultivars, P-845 did very well as expected, because it was recently released and is winter-hardy. One of the surprises was that TAM BAR 501 (developed in Texas and which normally has acceptable winter-hardiness) did poorer than normal, as did P-954, which is probably our most winter hardy release. Many experimental lines did very well.

The 2015 barley data are:

2015	Entry	Name	Lincoln	Mead	Average	Rank
			Yield	Yield	Yield	
			lbs/a	lbs/a	lbs/a	
bvt15	1	P-713	3108	2196	2652	5
bvt15	2	P-721	2491	1896	2194	20
bvt15	3	P-954	3115	2142	2628	7
bvt15	4	TAMBAR 501	2105	1391	1748	34
bvt15	5	NB09437	2548	1332	1940	29
bvt15	6	NB10403	1443	1351	1397	38
bvt15	7	NB10417	2682	2200	2441	13
bvt15	8	NB10425	2514	1647	2080	24
bvt15	9	NB10444	3058	2068	2563	11

bvt15	10	NB99845	2623	863	1743	**35**
bvt15	11	NB11414	2310	1822	2066	**25**
bvt15	12	NB11416	2742	1712	2227	**19**
bvt15	13	NB11430	2830	1420	2125	**21**
bvt15	14	NB12419	2577	2373	2475	**12**
bvt15	15	NB12421	2683	1779	2231	**18**
bvt15	16	NB12424	1799	1371	1585	**36**
bvt15	17	NB12425	2642	2030	2336	**14**
bvt15	18	NB12426	1610	1920	1765	**33**
bvt15	19	NB12434	3120	2482	2801	**4**
bvt15	20	NB12437	3526	2592	3059	**1**
bvt15	21	NB13401	2791	1447	2119	**23**
bvt15	22	NB13415	2776	1256	2016	**27**
bvt15	23	NB13430	1808	722	1265	**40**
bvt15	24	NB13435	2687	1964	2326	**15**
bvt15	25	NB13436	1606	1057	1331	**39**
bvt15	26	NB14401	2009	996	1503	**37**
bvt15	27	NB14403	2392	1855	2123	**22**
bvt15	28	NB14404	3150	2093	2621	**8**
bvt15	29	NB14405	3080	2124	2602	**9**
bvt15	30	NB14409	2507	1582	2045	**26**
bvt15	31	NB14412	3097	1373	2235	**17**
bvt15	32	NB14414	2734	1112	1923	**30**
bvt15	33	NB14417	2900	1087	1993	**28**
bvt15	34	NB14418	2583	1026	1804	**32**
bvt15	35	NB14422	3076	1395	2236	**16**
bvt15	36	NB14423	2579	1052	1816	**31**
bvt15	37	NB14428	3061	2084	2573	**10**
bvt15	38	NB14429	3232	2039	2635	**6**
bvt15	39	NB14430	3174	2465	2820	**2**
bvt15	40	NB14433	3446	2162	2804	**3**

The 2014 barley data:

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

The data for 2014-2016 are presented below:

	Yield (lbs/a)				Regional	Rank	**Location**	Rank
Name	Colby	Lincoln	Mead	Sidney	**Average**		**Average**	
P-713	4542	3108	2255	2385	**3073**	4	**2966**	6
P-721	4265	2491	2075	2155	**2746**	13	**2695**	13
P-954	4393	3115	2450	2530	**3122**	2	**3039**	4
NB10417	4153	1443	1900	1883	**2345**	15	**2402**	15
NB10444	4128	2682	2311	2950	**3018**	6	**2972**	5
P-845	4493	2514	2280	2509	**2949**	9	**2920**	8
NB11414	4411	3058	2369	2897	**3184**	1	**3097**	1
NB11416	4519	2623	2153	2106	**2851**	11	**2792**	11
NB11430	4426	2310	2650	1658	**2761**	12	**2804**	10
NB12419	4527	2742	2398	2196	**2966**	8	**2923**	7
NB12425	4665	2683	2517	2529	**3099**	3	**3078**	2
NB12434	4766	2642	2699	2173	**3070**	5	**3077**	3
NB12437	4447	1610	2430	1617	**2526**	14	**2628**	14
NB13401	4389	3120	2603	1800	**2978**	7	**2913**	9
NB13435	4422	2776	1641	2686	**2881**	10	**2739**	12
Average	**4436**	**2594**	**2316**	**2272**	**2905**		**2870**	

These data are interesting because the averages are developed in two ways. The first average is over locations (N=4) and the second is averaged over each trial (N=8). In general, there is good agreement.

VIII. ALLIED RESEARCH

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

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

IX. COMINGS AND GOINGS

All projects are more than crosses, selections, evaluations, data, and seed. At its heart, it is the people who make this research possible. Mr. Yavuz Delen and Ms. Semra Palali joined the project as M.S. students. Ms. Khatiba Bibi, Mr. Shamseldeen Eltaher, and Dr. Mohamed Saadlala joined the project as visiting scientists. We are extremely grateful for the excellent work that the team has done and continues to do.

Summary:

In 2015-2016 season, Nebraskans planted 1,370,000 acres of wheat and harvested 1,310,000 acres with an average yield of 54 bushels/acre for a total production of 70,740,000 bu. The 54 bu/a yield was a record yield. This production much higher than the production in 2015, and similar to the production in 2013. In 2014-2015 season, Nebraskans planted 1,490,000 acres of wheat and harvested 1,210,000 acres with an average yield of 38 bushels/acre for a total production of 45,980,000 bu. The high level of planted acres that were not harvested is likely due to winterkilling in western Nebraska due to fluctuating temperatures that year. In 2013-2014 season, Nebraskans planted 1,550,500 acres of wheat and harvested 1,450,000 acres with an average yield of 49 bushels/acre for a total production of 71,050,000 bu. In 2016, SY Wolf (7.4%), Winter Hawk (7.0%) Settler CL (6.9%) were the most widely grown varieties in Nebraska followed by Brawl CL Plus (5.0%), Overland (4.9%), Byrd (4.5%) TAM 111 (4.3%), and Buckskin (4.2%). An additional, 11 varieties were grown on less than 4% of the acreage. 2.4% were blends and 26% of our acreage where grown in varieties having individually less than 1% of the acreage. Of the reported varieties, we estimate 62% of Nebraska wheat acreage grew varieties developed by the collaborative USDA-ARS, University of Nebraska small grains breeding effort. This variety distribution is remarkable in that no variety has over 10% of the acreage. Compared to our adjacent states, individual cultivars are grown on much larger percentages of their wheat land.

No new wheat cultivars were released in 2016. The barley lines that were scheduled for release were resubmitted for seed increase. A total of seven winter triticale lines were recommended for release. Four of these lines are either being sold as certified seed in the fall of 2016 or will be sold in 2017 and one was licensed. The remaining two triticale lines were released due to licensing interest and potential for commercialization. The release documentation is at the USDA-ARS for their signature and the PVP applications are prepare and waiting for the final release notice to be completed. Our wheat and barley lines will have regional markets, but it seems our triticale lines (possibly due to the limited number of breeding programs) will have a national market, with the potential for an international market.

Our efforts on developing a public, transparent hybrid wheat platform took a major step forward with the successful receipt of a NIFA-IWYP grant on hybrid wheat. The University of Nebraska will be the lead institution and will work closely with Texas A & M University, CIMMYT, Kansas State University, Saaten-Union Recherche in France; the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany; and the University of Hohenheim in Germany. While the public sector may never release a hybrid wheat variety, we are committed to developing the fundamental knowledge that will be useful in developing hybrid wheat as a commercial product in the future. Hybrid wheat is one of the most promising ways of bringing the increased productivity and technology to wheat needed to feed an ever increasing and wealthier world.

As part of the people's university, we continue to breed wheat suitable for all of our constituencies. Due to reduced funding, our organic wheat efforts have lessened, but we are committed to work with organic producers. Our efforts in healthier grains have increased by the work on developing breeding protocols and lines with low Cd adapted to Nebraska. Breeding lines for improved biotic (disease and insect) and abiotic (winter survival, heat, and drought), better nitrogen use efficiency, and herbicide tolerance remain majors efforts. Our first two-gene Clearfield tolerant lines has one more year of qualification testing before it can be submitted to BASF for approval to be released.

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