IMPROVING WHEAT VARIETIES FOR NEBRASKA

2014 STATE BREEDING AND QUALITY EVALUATION REPORT

Report to the

NEBRASKA WHEAT DEVELOPMENT, UTILIZATION
AND MARKETING BOARD

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I. INTRODUCTION

Development research on Nebraska's 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). Very important 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 curtailed and many of the wheat quality analyses to evaluate our breeding material would not be available.

II. THE 2013-2014 NEBRASKA WHEAT CROP

1. Growing Conditions

The 2013-2014 growing season began with adequate moisture in most parts of the state. Adequate moisture continued for most of the state, but the southwest and west continued to have drought conditions in early spring. Overall, the temperatures were near normal and the season was considered close to average. Towards the end of the season, most of the crop had adequate to surplus moisture and those plants not injured early by the sporadic drought did very well. Overall, many wheat fields were very short due to the drought, but finished extremely well due to late rains.

2. Diseases

In 2014, drier-than-normal weather and cool temperatures early in the growing season delayed development of foliar fungal diseases. In addition, the amount of rust spores blowing in from southern states was small. As a result, foliar fungal disease levels were generally low during most of the growing season. Leaf rust arrived in mid-June in south-central and southeastern Nebraska, which was much later than its normal arrival time of mid- to late May. Statewide, levels of leaf rust were low. Other fungal diseases observed during the 2014 growing season included loose smut, common bunt, tan spot, Septoria tritici blotch, powdery mildew, and trace levels of Fusarium head blight (scab). Bacterial streak, also known as black chaff when it affects heads of wheat and other small grains, was the predominant disease in the eastern half of the state. At the Agricultural Research and Development Center (ARDC) near Mead and at Havelock Research Farm in Lincoln, very severe levels of bacterial streak were observed in wheat, oats, and triticale in breeding nurseries. Wheat soilborne mosaic virus (WSBMV) occurred sporadically in southeast Nebraska early in the growing season, but at much lower levels than in 2013. As temperatures warmed, symptoms of wheat streak mosaic virus (WSMV) and Triticum mosaic virus (TriMV) became more noticeable. Levels of virus diseases were generally low except in two fields in the southern Panhandle where high incidence and severity of WSMV were observed in June. Freeze injury was observed in some wheat fields throughout the state, but it was not as extensive as that observed in 2013. 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.

3. Insects

Nebraska continues to have small outbreaks of Hessian fly and the diseases vectored by aphids or mites (specifically WSMV - and the other mite-transmitted viruses and barley-yellow dwarf virus). However, the major concern remains the continued spread of wheat stem sawfly into Nebraska. This is an emerging pest and currently the most used resistance mechanism is through plant breeding (solid stem lines), which carries a yield drag. Hence, in collaboration with Montana State University and Colorado State University, we are looking for novel resistance genes and mechanisms. Unfortunately, breeding for this insect pest will require more time and resources in the future. We are past the stage of wondering if it will come and find a home in Nebraska. The Entomology Program at the UNL Panhandle Research and Extension Center continues to work with the UNL Wheat Breeding Program to evaluate existing and new sources of resistance. Our 2014 Wheat Stem Sawfly Survey shows a continued geographic expansion into Nebraska (Table 1). We have recorded several individual field locations with as high as 100% infestation within the sampled area. Survey efforts were expanded in 2014 to more sites across different counties in Nebraska.

Table 1. Mean proportion infested stems and number of fields sampled (in parenthesis) of wheat stem sawfly larvae from 2011-2014 in Nebraska and select adjacent Colorado and Wyoming counties. Means are based on 25 subsamples of 100 total wheat tillers randomly collected from field edges for each location (99 site years).

State	County	2011	2012	2013	2014
Colorado	Logan	--	0 (1)	0.3 (1)	0.8 (1)
	Sedgewick	--	0 (1)	0 (1)	--
Nebraska	Banner	7.6 (7)	13.3 (6)	13.1 (3)	21.8 (1)
	Box Butte	3.5 (6)	9.2 (4)	18.1 (4)	23.8 (1)
	Chase	--	--	--	0 (1)
	Cheyenne	2.8 (4)	12.3 (1)	15.5 (1)	19.3 (1)
	Dawes	--	7.5 (1)	7.5 (1)	13.8 (1)
	Deuel	--	0 (1)	--	--
	Franklin	0 (2)	0 (2)	0 (1)	--
	Garden	0.3 (1)	0.3 (1)	0 (1)	1.5 (1)
	Gosper	0 (2)	0 (2)	0 (2)	0 (2)
	Harlan	--	--	--	0 (1)
	Kearney	--	--	0 (1)	--
	Kimball	--	--	--	1.8 (1)
	Morrill	5.1 (2)	6.8 (2)	22.1 (2)	18.3 (1)
	Perkins	--	--	--	0 (1)
	Scotts Bluff	--	14.5 (3)	13.9 (4)	20.8 (1)
	Sheridan	0 (2)	0.2 (3)	3.5 (2)	1.3 (1)
	Sioux	--	0.5 (1)	--	0 (1)
Wyoming	Laramie	8.1 (2)	11.9 (2)	21 (2)	--

Work is underway to develop a laboratory colony of stem sawfly that could greatly expedite our cultivar evaluation timeline. Current stem sawfly resistant traits rely on solid stem traits for resistance. However, recent data from Nebraska (Table 2) indicate some variability in this trait between localities. This variability may in turn influence the reliability of this trait for stem sawfly resistance. Pith expression in wheat is somewhat determined by light intensity during development; therefore, it can vary accordingly. Montana has also noted this variability across its landscape as well.

Table 2. Mean (±SEM) wheat pith solidness ratings for select wheat varieties from State Variety Test Plots from three Nebraska counties. Ratings are from 5-25; where 5 = hollow and 25 = solid. Means based on 3 stems from five plants from four replicate plots per location. Varieties with an asterisk are generally referred to as "solid stem" varieties.

Variety	Deuel	Cheyenne	Dawes
Freeman	8±0.65	10±0.77	7±0.67
Warhorse*	19±1.08	25±0.17	18±1.31
Judee*	17±0.93	24±0.14	18±0.34
Bearpaw*	21±0.87	23±0.42	18±0.89
Pronghorn	6±0.3	8±0.74	6±0.66
Goodstreak	6±0.12	8±0.59	6±0.43
Hatcher	7±0.29	8±0.66	6±0.53

Lastly, for 2013 and 2014 we conducted a cage-infestation variety screen test (Table 3, "Cage") and evaluation of stem sawfly larval infestation in the Box Butte County State Variety Test (Table 3, "Field") for select varieties. All wheat varieties can become infested with the wheat stem sawfly (including solid stem varieties). However, mortality factors such as beneficial organisms and host-plant traits can limit the ability for a sawfly larva to complete development into a prepupa and eventually an adult wasp. Both variables (infestation and larval survival) are key to understanding both mechanisms of host plant resistance and the integration of these traits into the agricultural ecosystem. In our "cage" studies, a limited number of stem sawflies are introduced into cages containing a few varieties. In our "Field" study, natural populations (usually much larger number than our "cage" study) have access to a large number of varieties (many more than we sample). Therefore, in both studies, sawflies adults can make a choice as to where they deposit their eggs, but on much different land areas. It is clear from both studies that the solid-stem varieties (Bearpaw, Judee, and Warhorse) significantly reduce the survival of the wheat stem sawfly compared to many (but not all) hollow-stem varieties. In 2014, based on both "Cage" and "Field" studies, the wheat variety Warhorse had 0-9% stem sawfly survival and appears to be the most resistant of the wheat varieties we have tested thus far. It may also be noteworthy that some conventional hollow-stem varieties (e.g., Goodstreak) may have either a high stem sawfly mortality or a reduced insect preference. Lastly, in 2014, we included two barley varieties (Sidney and Stoneham – both are Russian wheat aphid resistant) to evaluate their susceptibility to stem sawfly. Neither barley variety had any evidence of infestation. Therefore, we are working with the UNL Wheat Breeding Program to evaluate some conventional wheat-barley crosses for potential novel sources of stem sawfly resistance.**Table 3. Mean percentage (±SEM) of wheat tillers with wheat stem sawfly frass (Infest) or with live larvae or prepupae (Larvae) for select winter wheat varieties and two barleys* for artificially-infested, common-garden plots (Cage) or from the Box Butte State Variety Trial (Field). Different letters between means within a column in a study indicate a significant difference at p-val < 0.05.**

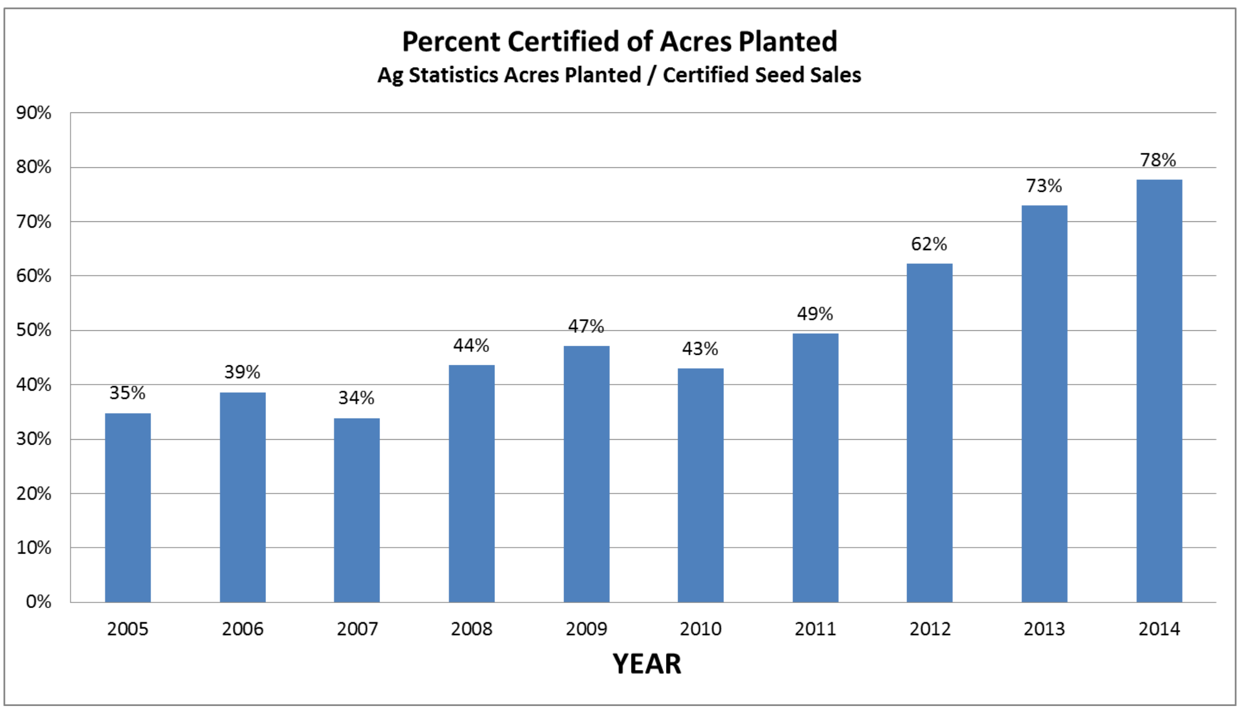
		2013		2014	
Cage	**Variety**	**Infest (%)**	**Larvae (%)**	**Infest (%)**	**Larvae (%)**
	Bearpaw	29.4 ± 0.2	7.1 ± 0.1	14 ± 0.1cd	8.7 ± 0.1cd
	Freeman	42.3 ± 0.25	4.2 ± 0.05	51.1 ± 0.2a	18.2 ± 0.05abc
	Goodstreak	23.6 ± 0.1	0 ± 0	9.6 ± 0.05cd	1.5 ± 0.05d
	Hatcher	37 ± 0.15	29.9 ± 0.15	33.2 ± 0.05ab	26.1 ± 0.1a
	Judee	17.3 ± 0.2	1.9 ± 0.05	6.9 ± 0.05d	4.4 ± 0.05d
	Kharkof	39.6 ± 0.25	8.3 ± 0.1	6.3 ± 0.05d	4.8 ± 0.05d
	Overland	32.7 ± 0.2	14.9 ± 0.15	26 ± 0.1bc	11.5 ± 0.1bcd
	Pronghorn	22.3 ± 0.15	10.9 ± 0.1	34.6 ± 0.05ab	21.5 ± 0.05ab
	Robidoux	20 ± 0.15	0 ± 0	9.6 ± 0.1cd	3.8 ± 0.05d
	Sidney*	--	--	0 ± 0d	0 ± 0d
	Stoneham*	--	--	0 ± 0d	0 ± 0d
	Turkey	--	--	11.1 ± 0.05cd	7.9 ± 0.05cd
	Warhorse	--	--	4.2 ± 0.05d	0 ± 0d
Field	**Variety**	**Infest (%)**	**Larvae (%)**	**Infest (%)**	**Larvae (%)**
	Bearpaw	--	--	38.7 ± 0.1d	18 ± 0.1de
	Freeman	36 ± 0.1c	2 ± 0.05d	63.3 ± 0.1c	29.3 ± 0.1bcd
	Goodstreak	42 ± 0.1c	20 ± 0.1bc	58.7 ± 0.1c	36 ± 0.1b
	Hatcher	61.5 ± 0.05ab	38.5 ± 0.1a	78.7 ± 0.05ab	52.7 ± 0.05a
	Judee	--	--	62.7 ± 0.05c	26 ± 0.05bcd
	NE09521	39 ± 0.1c	17 ± 0.1bcd	65.3 ± 0.1c	38 ± 0.1b
	Overland	72 ± 0.1a	34 ± 0.15ab	86.7 ± 0.05a	60.7 ± 0.1a
	Pronghorn	50 ± 0.1bc	7.5 ± 0.05cd	55.3 ± 0.1c	22.7 ± 0.1cd
	Robidoux	70 ± 0.1a	37.5 ± 0.1a	67.3 ± 0.05bc	36.7 ± 0.1b
	Turkey	48 ± 0.1bc	27 ± 0.1ab	60.7 ± 0.05c	33.3 ± 0.05bc
	Warhorse	--	--	28.7 ± 0.1d	9.3 ± 0.05e

4. <u>Wheat Production</u>

In 2013-2014 season, Nebraskans planted1,550,500 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. This production was almost 180% higher than the 2012-2013 crop, which bodes well for wheat producers. In 2012-2013 season, 1,470,000 acres of wheat were planted in Nebraska and 1,130,000 were harvested with an average yield of 35 bu/a for a total production of 39,550,000 bu. The 2012-2013 crop was one of the smallest crops in the last 50 years and certainly highlighted the effect of drought. In 2012, 1,380,000 acres of wheat were planted in Nebraska and 1,300,000 were harvested with an average yield of 41 bu/a for a total production of 53,300,000 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.

5. Cultivar Distribution

Nebraska did not take a variety survey in 2014, but has resumed the survey in 2015 (which has not been reported yet). In 2014, Settler CL (a one-gene Clearfield wheat) had the most reported acres of production followed by Overland, then Brawl CL+ (a two-gene Clearfield wheat), then Robidoux, Byrd, and Infinity CL (a one-gene Clearfield wheat). As Clearfield wheats require 100% certified seed planted every year, the total acreage of a variety within the state may be more for non-Clearfield wheat varieties that have some growers' planting back their harvested seed. 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. One important aspect is that using a "back of the envelope approach," the Nebraska Crop Improvement Association (NCIA), which has full access to certified seed production records, estimated that enough seed was produced in Nebraska to plant 78% of our wheat acreage. Nebraska has been a leader for planting certified seed, but this is major change since 1986 when approximately 25% of the wheat acres were sown to certified seed. In 2012-2013, using seed sales of certified seed, the top 10 lines were: Settler CL (15.4%), Overland (12.4%), Tam 111 (9.4%), AP502CL2 (6.3%), Winterhawk (5.6%), Wesley (5.1%), Pronghorn (5.0%), Infinity CL (4.3%), Art (3.6%), and Camelot (3.3%). In 2012, TAM 111 (12.8%) inched ahead of Overland (12.7%) as the most widely grown wheat cultivar in Nebraska, followed by Pronghorn (9.6%). Pronghorn and Goodstreak (5.1%) are tall (conventional height) wheat varieties that have consistently done well in the drought prone areas of western Nebraska. Buckskin (4.7%) decreased slightly, indicating that tall wheats, which are adapted to drought in the west, remain very popular (19.4% of the total state acreage).



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. Cultivars developed by the University of Nebraska wheat improvement program occupied 65.6% of the state acreage in 2012. Other public varieties occupied 17.4% (largely due to TAM 111) and private varieties occupied 17.0% (note the private cultivars do not include TAM 111 which was developed by Texas A&M but is marketed by Agripro) of the state acreage.

What is interesting is that no variety dominated the acreage. Variety diversity is useful, as it should reduce genetic vulnerability to disease and insect pests.

	--**Percent**------------------------------------									
Variety	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
2137	10.3	7.8	4.3	**3.5**	1.4	2.1	1.7			
2145				**1.0**	1.2	2.2				
Above				**1.3**						
Agripro Abilene	1.4	1.7	1.7		1.0					
Agripro Art								2.4	4.3	3.6
AgriPro AAP503 CL										1.1
AgriPro Dumas					1.4	1.2				
Agripro Hawken							1.2	2.1		
Agripro Jagalene		4.5	16.8	**23.8**	33.4	20.9	13.8	8.5	5.4	2.4
Agripro Ogallala	3.6	2.4	2.0	**1.4**	1.0	1.1				
Agripro Postrock						1.1	4.1	4.4	3.3	2.4
Agripro Thunderbird	1.8									
Agripro Thunderbird								1.1		
Agripro Thunderbolt	2.0	3.0	1.9	**1.9**	2.0	2.4	1.6	1.5	2.2	
Akron	1.2									
Alliance	11.5	13.6	10.1	**10.1**	7.2	6.1	6.1	6.0	3.9	3.7
Arapahoe	8.7	6.8	5.2	**2.9**	2.0	3.4	2.2	2.1	1.5	
Armour									1	2.6
Bond CL										1.1
Buckskin	7.3	4.9	3.7	**5.0**	3.5	3.4	3.3	4.5	5.9	4.7
Camelot									1.1	2.3
Centura	1.8	2.1	2.4	**1.9**	1.3	1.0				
Culver	2.5									
Goodstreak			1.7	**3.7**	3.6	5.1	5.0	6.5	4.4	5.1
Hatcher							1.2	1.5	1.8	2.1
Hawken									1.5	
Infinity CL						2.3	3.5	3.7	3.3	4.3
Jagger	3.9	2.8	3.1	**2.5**	1.7	1.5	1.1			
Karl/Karl 92	3.8	3.3	2.7	**2.7**	1.6	2.9	2.5	1.6	2.1	1.4
Millennium	6.1	11.1	10.7	**9.5**	7.2	9.4	13.2	11.9	7.6	5.9
Niobrara	5.4	3.5	2.2							
Overland							3.4	5.6	10.8	12.7
Overly					1.0	1.1				
Platte	1.0	1.3	1.6							
Pronghorn	10.3	10.4	11.4	**10.1**	12.2	10.6	12.1	13.7	10.4	9.6
Scout & Scout 66	1.1									
Settler CL										4.7
Siouxland	1.4									
TAM 111				**1.2**	1.6	3.2	6.5	7.4	8.1	12.8
TAM 112									1.2	
Vista	1.2									
Wahoo	1.8	1.7	1.8	**1.8**	1.1	1.5	1.1			
Wesley	3.6	5.9	5.5	**5.8**	7.2	7.7	4.8	4.1	4.2	2.0
Winterhawk									1.3	3
Z Other Private Varieties	3.4	4.4	4.0	**3.8**	2.8	4.1	5.0	3.6	5.4	4.5

Z Other Public Varieties	4.9	8.8	7.2	**6.1**	4.6	5.7	6.6	7.8	9.3	8.0
Total	100	100	100	**100**	100	100	100	100	100	100

6. New Cultivars

Based upon seed producers' input, the line NE05548 was recommended for release and formally released in January 27, 2014, as Husker Genetics Brand Panhandle. It was described in our previous annual report (available at: http://agronomy.unl.edu/documents/4128273/6410994/WheatAnnualReport2013.pdf) and will not be described here. In our work on nitrogen use efficiency (NUE) and mineral content in wheat (part of the TCAP project), we identified Panhandle as being a low Cd accumulating line. Cd is a toxic element and regulated in food. We also discovered that Freeman, the release before Panhandle is very good for NUE. It scavenges N better than other commercial cultivars. No other wheat line was recommended for release in 2014 though one line was recommended for licensing to our organic wheat community (NW07505, see below).

III. FIELD RESEARCH

1. Increase of New Experimental Lines

A number of lines are under increase for possible release in 2015 or 2016. NW07505 is a hard white semi-dwarf wheat that is derived from the cross Trego/Thunderbolt. It segregates for resistance to stem rust, is moderate resistant to leaf rust and wheat soilborne mosaic virus (or use abbreviation WSMV). It is moderately susceptible to stripe rust and susceptible to hessian fly, greenbug, black point, and barley yellow dwarf virus. In years when common bunt (stinking smut) was present in our organic tests, NW07505 was generally bunt free, indicating it is more resistant (based on data so far) to common bunt than many other lines we tested under organic conditions. One of its attributes is that it has above average quality at low protein levels. In organic production systems, it is often difficult to grow high protein lines, so having good end-use quality under organic production systems is very important.

NE07531 is derived from the cross HBA142A/HBZ//Ale (=HBK0630-4-5)/3/NE98574 (=CO850267/Rawhide)/4/Hallam. The HB... lines were gifted to Kansas State University by Pioneer when Pioneer reduced its hard red winter wheat breeding effort. NE07531 seems best suited for south central and southwestern Nebraska, as well as potentially irrigated production in western Nebraska. It is moderately resistant to stem, leaf, and stripe rust, WSBMV , and acid soils. It has some tolerance to Fusarium head blight. It is susceptible to wheat streak and triticum mosaic virus, and Hessian fly.

NE09517 is derived from the cross Jagger/Thunderbolt//Jagalene. NE09517 seems best suited for central to western Nebraska. It is resistant to stem rust, moderately resistant to stripe rust, and moderately susceptible to leaf rust. It is susceptible to barley yellow dwarf virus, WSBMV, Septoria tritici, and bacterial leaf streak, Hessian fly, and acid soils.

NE09521 is derived from the cross OK96717-99-6755/NI01824//NE00564 where the pedigree of OK96717-99-6755 is Abilene/2180//Chisholm, the pedigree of NI01824 is Intensivnaja/NE92458 (=PL83201/Redland)//VBF0168), and the pedigree of NE00564 is T81/NE91635 (=NE82671/NE82599). NE09521 is a moderately early, relatively tall, semi-dwarf wheat with average straw strength. It is moderately resistant to resistant to wheat stem rust; moderately resistant to moderately susceptible to stripe rust and WSMV; moderately susceptible to leaf rust and barley yellow dwarf virus; and susceptible to Hessian fly, greenbug, bacterial leaf streak, and wheat streak mosaic virus. It was tested in the SRPN in 2012 and 2013 (data available athttp://www.ars.usda.gov/Research/docs.htm?docid=11932) and in the Nebraska State Variety Trials (data available at: http://cropwatch.unl.edu/web/varietytest/wheat). Based upon the data we have collected so far, NE09521 seems to haveadapted to the Northcentral and Northern High Plains and be best suited for production in eastern Nebraska and states south and west of Nebraska where less disease resistance is needed. Based upon our end-use quality data to date, NE09521 would be lower in test weight and have average end-use quality. This line is being considered for release to certified seed producers in 2015. Compared to Wesley (moderately susceptible to susceptible for scab reaction and susceptible for DON accumulation) and Overland (moderately resistance to scab reaction and moderately resistant for DON accumulation), NE09521 is considered as being moderately resistant for scab reaction and susceptible for DON accumulation.

NE10589 is derived from the cross OK98697/Jagalene//Camelot. It has good testweight, is a taller semi-dwarf with medium late maturity. It is resistant to susceptible to Hessian fly, moderately resistant to stem, leaf, and stripe rust and bacterial streak. By markers, it may have the Lr37/Sr38/Yr17 translocation. This line seems to be very broadly adapted and was selected using phenotypic and genomic selection. This is a favorite line by yield and genomic selection. In considering its yield and test weight, in head-to-head comparisons, it was the best yielding line in my program of those lines near release.

		Yield			Test Wt.	
	Trials	% of NE10589	Significance	Trials	% of NE10589	Significance
Camelot	29	89	***	14	99	ns
Goodstreak	29	85	***	14	99	ns
Panhandle	19	87	***	8	98	ns
Freeman	19	96	**	8	97	**
NE07531	19	93	***	8	98	**
NE09517	20	94	**	8	101	ns
NE09521	20	93	***	8	99	ns
Robidoux	19	95	*	8	100	ns
NW07505	19	94	**	8	99	ns
Overland	29	95	**	14	100	ns
Settler CL	19	91	**	8	100	ns
Wesley	24	87	***	12	98	**

With the release of new varieties Overland, Camelot, Freeman, Goodstreak, McGill, Panhandle, Robidoux, and Settler CL, many of the most advanced current breeding lines are not expected to be released.

2. Nebraska Variety Testing

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
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.

In 2013, the top ten entries for dryland production (11 environments) were:

	Yield		**Yield**
Entry	bu/a	Entry	bu/a
LCS Mint	57.03	NE06607	55.07
Overland	55.82	NE08499	54.88
NE09517	55.28	T158	54.81
NE09521	55.24	NI08708	54.80
Freeman	55.17	BL11002	54.40

As would be expected the two lowest yielding lines were Scout 66 (44.38 bu/a) and Turkey (42.10 bu/a) which were 22% and 26% lower yielding (respectively) than the highest yielding line.

In 2012, the top ten entries for dryland production were:

	Yield		**Yield**
Entry	bu/a	Entry	bu/a
NE06545	59.31	WB Armour	55.38
SY Wolf	58.60	NI08708	55.13
McGill	56.44	NW0366	55.08
Overland	55.78	NE08659	55.06
Mattern	55.53	Settler CL	54.96

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

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.

The top ten lines in 2012 were:

	Yield		Yield
Entry	bu/a	Entry	bu/a
WB-Aspen	86.87	NI07703	77.80
Brawl CL Plus	85.10	NE06430	77.80
Anton	82.63	SY-Wolf	76.57
WB- Armour	79.17	Byrd	76.47
Mattern	78.13	Settler CL	75.73

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. In 2014 (next page), we were able to harvest all of the dryland sites (Lincoln, North Platte, \and Alliance) and the irrigated site (Hemmingford). We have made considerable progress in reducing height and lodging, but additional disease resistance is needed. The data is color coded with dark green having the greatest values and red having the lowest values. It should be noted that the tallest wheats will be coded red (undesirable for this nursery), while the highest yielding and test weights, will be in dark green. The yield data from Lincoln was not correlated with the data from Alliance or the irrigated site, however, the yield data from Alliance was weakly correlated with the data from the western irrigated site, indicating some similarities among the sites and that the rainfed site at Alliance received enough moisture to partially mimic the irrigated site. The alternative explanation is that both suffered from wheat stem sawfly infestation ,which may have made the yields at both sites more similar. he correlation among rainfed and irrigated trials, indicated that the no trial could explain more than 25% of the variation in another trial. Hence, the continued testing in different locations is warranted because each location is giving us new data. 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			

Data from 2013:

Name	Lincoln bu/a	Alliance bu/a	Dryland Avg. bu/a	Rank	Sidney Irr. bu/a	Rank	Testweight lbs/bu	Height Avg in
Antelope	68.5	42.4	55.45	37	93.5	35	61.3	34.10
NI04421	66.5	52.7	59.60	18	111.1	2	62.9	34.13
NI06736W	81.5	48.3	64.90	5	99.5	25	61.7	32.30
NI06737W	72.2	42.1	57.15	32	101	23	62.4	33.70
NI07703	69.2	48.8	59.00	22	101.4	22	61.9	33.87
NI08707	67.8	53.3	60.55	15	109.9	3	60.8	32.67
NI08708	71.3	46.5	58.90	23	104.7	15	61.4	33.10
NI09707	65.3	48.7	57.00	33	109.7	4	61.6	31.73
NI09710H	76.8	49.7	63.25	7	95.3	33	60.1	33.23
NI10707	67.9	47.8	57.85	29	98.3	28	61.2	36.17
NI10712	64.3	49.0	56.65	34	107.7	6	61.4	35.50
NI10718W	67.5	54.6	61.05	13	107.1	7	62.5	34.43
NI10720W	68.5	50.8	59.65	17	112.3	1	62.8	33.43
WESLEY	74.0	48.2	61.10	12	103.8	17	61.2	33.17
Settler CL	69.8	46.9	58.35	28	106.2	13	61.8	32.83
NE09481	73.4	51.7	62.55	10	103.9	16	62.5	32.80
NW07534	65.1	48.2	56.65	34	106.3	12	61.2	31.37
NI12702W	84.9	45.8	65.35	2	85.8	38	61.6	34.33
NI12709	81.0	45.0	63.00	8	99.3	26	62.6	33.97
NI12713W	72.4	43.0	57.70	30	99.3	26	62.2	34.27
NI13701	58.5	44.8	51.65	39	76.7	40	61.3	36.57
NI13702	56.1	40.8	48.45	40	86.4	37	62.3	36.53
NI13703	73.1	52.7	62.90	9	106.9	9	63.4	33.87
NI13704	72.0	44.7	58.35	27	105.1	14	61.6	34.73
NI13705	72.6	47.5	60.05	16	106.6	10	63.7	34.90
NI13706	80.1	50.0	65.05	3	98.3	28	61.8	32.57
NI13707	69.5	48.2	58.85	24	103.3	18	62.6	31.43
NI13708	76.5	53.6	65.05	3	95.4	32	62.6	31.80
NI13709	68.3	41.1	54.70	38	94.3	34	60.8	35.10
NI13710	68.2	44.8	56.50	36	106.6	10	63.8	33.43
NI13711	71.4	49.7	60.55	14	107	8	62.9	34.97
NI13712	68.6	48.9	58.75	25	102.2	21	63.1	33.47
NI13713	71.6	47.6	59.60	19	102.4	20	63.5	33.70
NI13714	75.2	43.5	59.35	20	92	36	62	33.10
NI13715	68.0	46.5	57.25	31	100.6	24	61.5	35.93
NI13716	74.9	47.9	61.40	11	96	30	61.6	34.53
NI13717	81.3	48.3	64.80	6	108.7	5	62.4	35.33
NI13718	69.5	47.4	58.45	26	85.7	39	60.6	33.77
NI13719	71.0	47.5	59.25	21	95.5	31	61.1	34.80
NI13720	83.6	47.5	65.55	1	102.5	19	61.9	31.10
Mean	71.45	47.66	59.555		100.72		61.99	
LSD	7.87	9.11	8.49		11.44		1.1	
CV	6.74	11.75	9.245		6.94		1.09	
Heritability	0.98	0.52	0.75		0.98		0.98	

Data from 2012:

	Lincoln	N. Platte	Alliance	Kansas	**Average**	**Rank**	**NE. Avg.**	**NE-Rank**	Height	Anthesis	TestWT
name	bu/a	bu/a	bu/a	bu/a	bu/a		bu/a		(in)	(Julian day	lbs/bu
Antelope	44.70	46.10	48.20	60.00	**49.75**	**33**	**46.33**	**30**	36.44	125.5	63.98
TAM111	50.20	52.30	51.70	71.10	**56.33**	**10**	**51.40**	**13**	24.80	118.9	52.23
WESLEY	52.20	45.90	52.90	61.60	**53.15**	**21**	**50.33**	**16**	29.11	128.5	57.87
NI04421	61.30	56.80	55.00	71.00	**61.03**	**1**	**57.70**	**3**	20.57	123.1	48.89
NI06736W	39.90	52.20	44.60	79.30	**54.00**	**19**	**45.57**	**33**	32.52	117.4	60.97
NI06737W	41.00	41.60	46.00	74.40	**50.75**	**29**	**42.87**	**37**	36.29	117.2	63.50
NI07703	45.50	49.70	48.00	82.10	**56.33**	**10**	**47.73**	**24**	27.24	117.9	56.38
NI08707	56.40	41.20	50.30	75.50	**55.85**	**13**	**49.30**	**20**	27.43	117.8	55.08
NI08708	54.80	51.00	54.30	74.40	**58.63**	**6**	**53.37**	**8**	22.46	119.1	49.85
NI08714	38.20	34.30	52.20	61.60	**46.58**	**40**	**41.57**	**40**	40.52	117.3	65.94
NI09703	57.90	41.60	52.50	58.50	**52.63**	**23**	**50.67**	**15**	29.56	125.1	56.55
NI09707	49.20	44.30	48.40	69.80	**52.93**	**22**	**47.30**	**26**	31.77	116.1	57.96
NI09710H	58.10	48.60	50.30	72.90	**57.48**	**8**	**52.33**	**10**	23.44	122.7	52.05
NI10703	50.80	40.90	41.00	59.30	**48.00**	**37**	**44.23**	**35**	38.74	123.2	65.65
NI10705	50.50	34.10	51.40	50.90	**46.73**	**39**	**45.33**	**34**	39.44	129.6	67.68
NI10707	48.30	42.90	48.80	69.10	**52.28**	**24**	**46.67**	**28**	32.89	118.6	59.83
NI10712	51.30	46.20	49.10	73.60	**55.05**	**16**	**48.87**	**21**	28.62	124.4	58.01
NI10718W	60.20	51.70	51.70	69.30	**58.23**	**7**	**54.53**	**6**	22.51	124	50.84
NI10720W	52.10	43.20	49.00	62.90	**51.80**	**27**	**48.10**	**22**	32.37	127.5	60.62
Settler C	54.60	49.10	51.80	81.80	**59.33**	**3**	**51.83**	**12**	22.28	121.4	51.89
NE08402	51.70	31.80	42.00	73.50	**49.75**	**33**	**41.83**	**39**	37.94	118.8	65.25
NE08410	49.00	32.20	44.90	64.30	**47.60**	**38**	**42.03**	**38**	39.34	119.9	65.75
NE08509	59.20	46.70	52.20	58.20	**54.08**	**18**	**52.70**	**9**	26.57	124	53.19
NE09481	55.40	45.30	55.90	80.60	**59.30**	**4**	**52.20**	**11**	22.40	116.2	49.87
NE09499	57.10	37.20	49.30	65.20	**52.20**	**25**	**47.87**	**23**	31.96	119.7	58.22
NW07534	66.80	57.20	50.80	69.20	**61.00**	**2**	**58.27**	**2**	20.76	123.8	48.85
NI12701	56.50	45.70	47.60	57.30	**51.78**	**28**	**49.93**	**17**	31.64	124.5	57.71
NI12702	65.70	60.20	50.20	60.50	**59.15**	**5**	**58.70**	**1**	21.57	127.9	50.16
NI12703	71.20	46.10	43.90	61.30	**55.63**	**14**	**53.73**	**7**	24.91	124.7	52.20
NI12704	50.00	44.40	43.90	61.10	**49.85**	**32**	**46.10**	**31**	36.37	124.3	63.89
NI12705	59.20	50.70	54.30	50.00	**53.55**	**20**	**54.73**	**5**	26.58	127.2	52.93
NI12706	50.50	50.50	52.20	76.60	**57.45**	**9**	**51.07**	**14**	24.69	116.9	51.86
NI12707	45.00	45.60	50.80	65.90	**51.83**	**26**	**47.13**	**27**	33.38	120	60.13
NI12708	48.60	38.00	44.60	70.80	**50.50**	**30**	**43.73**	**36**	36.58	122.5	65.03
NI12709	49.50	47.80	51.40	76.40	**56.28**	**12**	**49.57**	**19**	26.86	121.8	55.89
NI12710	53.60	37.60	48.50	57.50	**49.30**	**35**	**46.57**	**29**	36.86	124.7	63.52
NI12711	69.50	45.20	53.60	52.70	**55.25**	**15**	**56.10**	**4**	25.03	126.7	51.91
NI12712	54.10	40.10	48.50	58.10	**50.20**	**31**	**47.57**	**25**	34.52	126.1	61.87
NI12713	57.30	46.30	45.60	69.00	**54.55**	**17**	**49.73**	**18**	28.24	118.3	54.85
NI12714	42.00	41.70	53.50	59.40	**49.15**	**36**	**45.73**	**32**	37.91	122.3	64.07
GRAND M	**53.23**	**45.10**	**49.52**	**66.67**	**53.63**		**49.28**		**30.08**	**122.14**	**57.57**

The three-year averages for the lines tested in all three years (2012-2014) is below. The importance of the sustained effort in irrigation is very obvious in 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 irrigated environments (101 bu/a) is roughly twice the average of the rainfed environments for the same years. As can be seen in the table, Robidoux continues to be an excellent rainfed wheat with broad adaptation. Settler CL continues to be one of our most broadly adapted wheats from rainfed to irrigated. Additional wheat experimental lines perform well 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?"

2012-2014	Linc.	N.Platte	Alliance	**Average**	**Dryland**	**Alliance IRR**	**IRR**
	Yield	Yield	Yield	**Yield**	**Rank**	Yield	**Rank**
	bu/a	bu/a	bu/a	**bu/a**		bu/a	
name						yb_sd11	
Antelope	60.47	42.85	49.23	52.25	**11**	97.60	**9**
NE09481	65.83	44.90	50.57	55.73	**7**	94.43	**10**
Robidoux	68.90	49.00	54.17	58.53	**1**	94.27	**11**
NI08707	67.60	45.40	55.67	57.91	**3**	105.87	**2**
NI09707	62.87	45.15	53.87	55.28	**9**	100.10	**7**
NI10718W	67.10	48.10	55.73	58.42	**2**	100.90	**5**
NI10720W	67.17	46.30	47.97	55.29	**8**	99.67	**8**
NI12713W	65.23	45.45	47.20	53.99	**10**	106.23	**1**
NW07534	67.27	54.15	50.70	57.65	**4**	104.07	**3**
Settler CL	65.47	48.25	51.77	56.28	**6**	103.53	**4**
WESLEY	65.77	46.40	53.67	56.91	**5**	100.57	**6**
Mean	**65.79**	**46.90**	**51.87**			**100.66**	

4. Nebraska Intrastate Nursery:

The 2014 Nebraska Intrastate Nursery (NIN) was planted at seven locations in Lincoln, Mead, Clay Center, McCook (added due to generous support from ConAgra, now Ardent Mills), North Platte, Sidney, and Hemingford, NE. All sites were harvested. A collaborative site was in Kansas (data not shown). The low yields at Mead were due to heavy and persistent rains, which led to severe bacterial streak infections. Lincoln also had bacterial streak disease but it did not drastically reduce grain yield. The other tested sites all had normal to above normal grain yields. The quality of the trials was good and the CVs (coefficient of variation, a measure of error variation and the ability to separate lines statistically) were all good. Of the lines tested in 2014, NHH11569 (a two-gene Clearfield line did particularly well). Unfortunately, when sprayed with herbicide, it has an unacceptable injury level due to modifier genes of the two gene herbicide resistance. It should become a very valuable parent.

Two other single gene lines (NH11489 and NH11490, all single gene lines have been dropped) were agronomically excellent and will become parents. NE09517 and NE10589 under increase for possible release continued to do very well. The value of the irrigated program continues to be shown in NI13706, which did very well in this nursery and was first identified in the IRDR nursery. Of the released lines, Overland, Camelot and Robidoux had very good years. Included in the data are data on bacteria streak tolerance. Overland, Freeman, and a number of other lines including NHH11569 are better for tolerance/resistance to this disease. As expected Cheyenne and Scout 66 were the lowest-yielding lines in the trial, though it was a surprise to see Cheyenne have a higher yield than Scout 66. As in the past, the correlation among sites ranged from r= -0.06 n.s. (n= 60, North Platte and Kansas) to a high of r =0.66** (n=60, Lincoln with Clay Center) indicating in this year both sites provided somewhat similar data though either site could explain less than half of the variation at the other site. The low correlation between sites emphasizes that it is important to continue testing at all of our sites to represent the possible growing areas for our advanced lines.

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**						

In 2014 NIN advance wheat, 50 wheat cultivars were analyzed for 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 62.5±7.3: 66% cultivars had high hardness (60.0-80.0) including checks Overland, Settle CL, and Scout 66; 30% cultivars had low hardness (< 60.0) including checks Wesley, Goodstreak and Cheyenne; and other cultivars had very high hardness (≥ 80.0). The kernel diameters and weights were 2.7±0.1 mm and 32.8±1.8 mg, respectively. All cultivars including all checks had large diameter (≥ 2.4 mm). Ninety eightpercent of the cultivars including all checks had large seed weights (≥ 30.0 mg).

There were significant differences in milling properties among these cultivars. The flour, bran and short yields were 72.7±1.4 %, 24.5±1.2%, and 2.8±0.5%, respectively. Except of NW11511, all cultivars including all checks produced high flour yield (≥ 68.0%). The bran, short and milling scores were 3.4±0.7, 3.1±0.7, and 3.4±1.2, respectively. Most cultivars including all checks gave fair or better bran cleaning and milling performance.

There were significant differences in ash contents among these cultivars. The ash contents of white flour at 14% mb were 0.37±0.04%. All cultivars including all checks had low ash content (< 0.50%). There were significant differences in protein contents among these cultivars. The protein contents of whole wheat at 12% mb were 13.7±0.6%. All cultivars including all checks had high protein contents of whole wheat (≥ 12.0%). The protein contents of white flour at 14% mb were 12.6±1.0%. After milling, protein contents were lost 0.3±0.6%. All cultivars including all checks had high protein contents of white flour (≥ 10.0%). The protein contents significantly effected on dough rheological properties and bread-making performance.

There were significantly differences in dough rheology among these cultivars. The flour water absorptions (abs) at 14% mb were 65.5±1.9%. Except of NW11511 and NE05548, all other cultivars including checks had high water abs (≥ 62.0%). The peak times (PT), which indicated dough extensibility, were 4.94±1.43 min. 72% cultivars, including checks Overland and Goodstreak, obtained good dough extensibility (PT 3.0-6.0 min), 6% cultivars (NI04421, Scout 66, and NE13434) obtained small dough extensibility (PT < 3.0 min), and the rest of cultivars obtained very large dough extensibility (PT ≥ 6.0 min), including Settler CL. The peak torques (PQ), which were dough maximum strengths, were 52.3±4.1 %TQ. 72% cultivars, including checks Wesley and Scoutt6, gave good dough strengths (PQ 45.0-55.0 %TQ), 4% cultivars (NE06545 and Settler CL) gave weak dough strengths (PQ < 45.0 %TQ), and the remaining cultivars gave very strong dough strength, including checks Wesley, Scott 66 and Cheyenne. The mixing tolerance rate (TR) were 3.8±0.8. The total areas (TA) in 8 min were 142±21 %TQ·min. Both TR and TA indicated dough resistances in mixing. Except for NI04421, which got low dough resistance in mixing (TA < 100 %TQ.min), all cultivars including checks got good dough resistance in mixing (TA 100 - 200 %TQ·min). 84% cultivars got fair or better than fair tolerance score.

There were significant differences in bread-making performance among these cultivars. The baking water abs at 14% mb were 63.6±0.9%. With the exception of NW11511 and SCOUT66, all other cultivars including other checks had high water abs (≥ 62.0%). The mixing times (MT) were 5.25±1.46 min. 74% cultivars, including checks Wesley, Overland, Goodstreak, Scott 66 and Cheyenne, gave normal MT (3.0-6.0 min), and the other cultivars including checks Settler CL gave very long MT (≥ 6.0 min). The dough handling rates were 4.0±0.2 and proof times were 53.5±5.2 min. The weight losses were 19.9±0.7%. The loaf volumes and specific volumes were 939±30 cc and 6.76±0.30 cc/g, respectively. The slice areas were 117±3 cm^2. Except for NW11511, all other cultivars including checks got volumes ≥ 850 cc or specific volumes ≥ 6.12 cc/g. After stored overnight, the breadcrumb firmness was 3017±390 Pa. The crumb brightness was 151±8. The cell numbers were 6835±275. The cell diameters were 2.08±0.12 mm. The non-uniformity was 8.04±35.51. The cell elongation was 149±0.02. The overall bread rates were 4.4±0.4. All cultivars including checks got fair or better than fair bread quality.

The data for 2013 are:

	Mead	Lincoln	C Center	McCook	Alliance	Average	Rank	Hutcheson	NE+KS Avg	Rank	Avg. L and CC	Average
								KS			Test Wt	Height
name	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a		Bu/a			lbs/bu	(in)
WESLEY	70.0	66.6	73.3	43.1	56.5	61.9	46	61.7	61.9	47	56.95	39.2
OVERLAND	71.0	73.7	73.8	39.6	59.8	63.6	31	73.9	65.1	18	58.9	42.4
NE01481	70.6	71.1	67.4	38.9	49.8	59.6	53	66.0	60.5	51	57.75	42.7
NE06430	72.8	76.8	73.1	44.5	56.0	64.6	20	67.4	65.0	20	58.7	42.1
NE06545	80.6	82.4	72.4	40.6	61.2	67.4	5	64.3	67.0	6	56.4	40.9
NE06607	76.5	74.8	76.7	46.6	58.6	66.6	7	64.0	66.3	10	58.45	41.1
NE07486	75.9	72.8	79.6	46.7	52.8	65.6	14	71.9	66.5	7	59.4	41.5
NE07531	77.8	77.5	83.3	43.4	60.4	68.5	3	68.9	68.5	2	58.7	41.6
NE08499	76.5	77.4	74.5	44.5	57.6	66.1	10	57.8	64.9	22	59.45	42.5
NE08659	59.5	60.3	71.7	32.2	54.5	55.6	57	66.5	57.2	57	57.6	42.4
NE09517	73.4	73.1	82.4	39.6	60.7	65.8	11	64.3	65.6	14	60	43.3
NE09521	75.4	70.8	77.5	36.1	62.5	64.5	22	65.6	64.6	23	58.05	42.0
NE10418	70.7	72.1	71.4	40.2	55.2	61.9	44	67.2	62.7	42	59.45	43.8
NE10442	79.8	77.4	66.8	39.1	58.6	64.3	23	61.7	64.0	29	60.25	42.2
NE10478	74.3	77.9	81.3	45.7	56.5	67.1	6	69.8	67.5	4	60.9	40.3
NE10507	79.2	82.2	73.7	41.8	55.5	66.5	8	65.7	66.4	9	56.95	41.5
NE10589	79.8	80.4	71.4	46.6	68.5	69.3	1	65.2	68.7	1	59.1	41.6
NE10625	73.4	71.7	71.3	40.3	61.8	63.7	30	57.8	62.9	39	58.75	41.6
NI04421	69.2	71.1	67.5	53.0	55.6	63.3	35	67.1	63.8	30	58.1	41.4
NE05496	66.1	67.5	78	54.0	54.8	64.1	24	66.6	64.4	24	57.85	42.1
NE10683	78.9	84.0	77.2	40.5	58.0	67.7	4	70.0	68.0	3	57.1	41.6
NE11415	71.2	76.9	74.7	41.8	55.0	63.9	27	65.6	64.2	26	59.5	40.5
NE11455	69.5	77.2	73.1	37.6	55.8	62.6	39	65.2	63.0	37	60.35	42.2
NE11472	74.2	76.6	73.3	44.4	55.9	64.9	18	67.1	65.2	15	59.65	41.8
NE11482	74.7	76.5	74.3	44.6	57.3	65.5	17	62.9	65.1	17	58.85	43.1
NE11499	73.4	72.7	71.3	49.0	49.8	63.2	36	65.3	63.5	31	60.2	39.9
NE11536	73.8	60.6	74.6	43.6	58.2	62.2	43	66.0	62.7	41	58.35	40.8
NE11560	75.6	80.8	74.3	31.1	57.5	63.9	28	60.8	63.4	34	58.05	40.5
NE11607	73.2	72.1	61.4	45.7	57.1	61.9	45	64.8	62.3	43	54.5	42.7
Camelot	71.3	65.9	76.9	46.5	61.8	64.5	21	68.4	65.0	19	58.45	42.7
NH10665	76.6	70.0	71.6	43.4	56.0	63.5	33	61.1	63.2	36	59.3	43.6
NH11489	72.2	77.6	73.9	44.2	59.6	65.5	16	71.6	66.4	8	59.15	41.3
NH11490	74.7	81.7	74.1	49.6	62.6	68.5	2	61.1	67.5	5	60.95	40.8
NH11563	77.0	73.7	73.6	35.9	58.6	63.8	29	66.3	64.1	27	59.05	43.8
NH11565	76.2	74.8	76.8	31.3	53.0	62.4	41	66.5	63.0	38	59.25	39.7
NH11668	64.7	69.0	72.9	37.6	56.7	60.2	52	58.9	60.0	52	59.2	42.0
NHH09655	67.6	65.3	71.7	32.9	50.0	57.5	56	57.3	57.5	56	55.7	39.9
NHH11569	68.6	68.7	74.6	46.6	53.9	62.5	40	59.8	62.1	44	59.5	43.3
NHH11638	78.0	78.9	70.9	48.4	51.4	65.5	15	68.2	65.9	11	60.15	42.9
Settler CL	67.9	68.0	72.7	52.4	56.0	63.4	34	69.2	64.2	25	58.7	41.0
NI04420	77.7	76.7	75.2	40.4	58.5	65.7	12	60.3	64.9	21	59.7	42.0
NI07703	73.7	65.8	71.6	42.4	59.9	62.7	37	63.8	62.8	40	57.9	41.5
NI08708	70.3	69.0	74.5	41.4	62.6	63.6	32	60.9	63.2	35	57	41.0
NI09710H	71.9	69.1	76.8	42.9	67.8	65.7	12	66.9	65.9	12	55.25	40.2
NI10712	66.2	63.3	68	36.2	59.8	58.7	54	61.2	59.1	55	55	41.5
NI10718W	72.0	67.6	70	38.0	54.6	60.4	50	62.1	60.7	50	57.15	41.4
NI12702W	73.7	73.0	72.2	44.7	60.3	64.8	19	59.7	64.1	28	59.85	42.4
NW03666	75.0	67.2	80.8	50.8	57.8	66.3	9	61.6	65.6	13	58.8	42.3
NW07505	71.0	70.1	75.1	42.0	61.9	64.0	26	60.4	63.5	32	57.6	42.6
NW09627	57.1	62.4	77.8	45.5	64.5	61.5	47	60.3	61.3	48	57	40.3
NW10487	53.0	54.9	67.7	41.7	59.1	55.3	58	61.0	56.1	58	55.55	42.0
NW11510	72.7	76.9	62.6	40.0	53.4	61.1	48	67.1	62.0	46	59.05	41.6
NW11511	78.5	73.6	64.3	46.6	57.2	64.0	25	71.6	65.1	16	57.55	40.5
NW11590	70.0	68.9	67.5	40.4	54.9	60.3	51	54.2	59.5	53	58.65	42.0
NW11598	69.1	74.4	72.6	40.4	56.9	62.7	37	68.1	63.5	33	58.7	41.0
NE05548	68.0	66.6	72.1	38.4	59.9	61.0	49	59.8	60.8	49	57.95	44.8
NE11688	76.2	78.3	64.6	38.4	54.4	62.4	42	60.3	62.1	45	55.95	42.1
GOODSTREAK	64.2	59.6	66.5	40.4	62.2	58.6	55	64.7	59.5	54	58.7	43.8
SCOUT66	51.2	47.7	60	37.9	51.0	49.6	59	52.0	49.9	59	58	44.4
CHEYENNE	41.1	39.1	56	40.0	44.3	44.1	60	53.4	45.4	60	57.85	47.1
GRAND MEAN	**71.4**	**71.22**	**72.45**	**42.21**	**57.37**	**62.932**		**63.99**				
LSD	8.54	6.42	8.79	11.27	8.38			7.2				
CV	**7.37**	**6.45**	**7.5**	**13.17**	**7.55**			**6.93**				
Heritability	**0.99**	**0.99**	**0.72**	**0.98**	**0.98**			**0.98**				

The 2012 data are presented below:

name	Kansas	Mead	Linc.	Clay Cen.	N. Platte	McCook	Sidney	Heming.	Avg.	NE Avg.	Rank	NE Rank
	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a
WESLEY	56.2	66.3	50.1	42.4	42.1	71.9	62.3	26.5	52.23	51.66	38	41
Overland	61.9	78.6	57.6	63.3	47.0	76.6	66.4	22.4	59.23	58.84	7	6
NE05496	62.4	57.6	50.0	48.6	38.6	77.3	69.9	25.3	53.71	52.47	29	36
NE05548	41.1	60.0	47.6	50.5	36.7	59.4	63.0	23.6	47.74	48.69	55	54
NE06430	59.8	63.0	49.6	51.6	45.1	79.3	65.6	25.5	54.94	54.24	21	23
NE06545	62.1	72.0	59.8	64.5	54.2	82.0	60.5	26.6	60.21	59.94	5	3
NE06607	57.5	65.8	51.9	54.4	44.0	75.4	60.0	25.2	54.28	53.81	25	26
NE07486	79.0	67.0	51.3	60.8	52.1	79.8	67.3	24.7	60.25	57.57	4	11
NE07531	55.7	60.6	50.7	51.7	42.2	79.9	60.5	26.1	53.43	53.10	32	30
NE07627	45.4	66.9	51.0	54.4	44.2	69.9	61.9	25.5	52.40	53.40	36	28
NE08457	55.2	57.4	50.5	49.2	40.6	58.3	49.9	24.4	48.19	47.19	53	56
NE08476	50.3	62.9	51.7	61.5	38.5	54.7	61.9	23.7	50.65	50.70	45	45
NE08499	61.1	66.7	51.3	54.4	46.8	75.3	66.7	26.4	56.09	55.37	15	14
NE08527	49.7	68.5	54.7	55.1	32.9	62.0	52.2	25.3	50.05	50.10	48	48
NE08555	63.6	62.3	50.4	59.2	42.8	65.9	56.2	26.6	53.38	51.91	33	38
NE08659	41.1	64.2	55.1	60.1	27.4	64.2	61.5	25.1	49.84	51.09	49	43
NE09491	49.6	64.6	45.2	53.4	37.9	65.4	59.3	26.5	50.24	50.33	47	46
NE09495	28.2	69.3	56.0	26.3	47.0	73.6	61.6	21.7	47.96	50.79	54	44
NE09499	53.2	64.2	55.0	43.7	36.7	67.4	59.2	23.3	50.34	49.93	46	50
NE01481	51.7	78.9	63.0	57.1	47.7	73.4	63.2	25.0	57.50	58.33	11	9
NE09517	67.0	63.3	49.2	64.6	50.5	74.9	46.7	25.8	55.25	53.57	20	27
NE09521	61.6	73.8	51.0	61.4	54.8	75.5	65.1	27.2	58.80	58.40	9	8
NE09637	34.9	62.8	52.4	39.3	29.3	68.3	53.3	25.4	45.71	47.26	58	55
NE10418	60.8	62.1	43.5	50.5	47.7	75.9	63.9	24.4	53.60	52.57	31	34
NE10431	54.5	65.4	54.4	55.5	46.0	79.2	58.1	25.2	54.79	54.83	22	18
NE10442	72.2	60.6	42.2	55.8	48.6	79.5	58.2	25.3	55.30	52.89	19	32
NE10449	46.2	60.8	53.3	56.9	34.1	61.6	53.8	24.2	48.86	49.24	51	52
NE10478	81.6	67.9	48.4	61.1	51.7	87.2	65.8	30.7	61.80	58.97	1	5
NE10507	67.3	72.5	62.1	71.3	49.1	81.5	62.7	25.8	61.54	60.71	3	2
NI04421	59.6	68.8	59.3	64.4	54.9	76.7	64.9	26.0	59.33	59.29	6	4
Camelot	48.0	58.8	47.4	50.4	40.8	61.7	62.4	23.3	49.10	49.26	50	51
NE10509	44.9	71.1	63.6	49.8	42.6	66.9	62.9	28.3	53.76	55.03	28	16
NE10514	49.0	61.9	47.9	57.8	42.8	72.2	59.2	30.8	52.70	53.23	35	29
NE10517	56.6	67.6	44.6	54.8	41.1	63.3	58.1	28.1	51.78	51.09	42	42
NE10522	46.3	58.4	41.0	48.3	42.9	64.3	61.2	27.1	48.69	49.03	52	53
NE10529	50.4	75.2	60.6	64.6	48.3	65.8	61.2	27.9	56.75	57.66	13	10
NE10559	60.6	61.8	43.5	51.5	41.2	63.4	64.7	26.0	51.59	50.30	43	47
NE10589	59.0	74.4	64.8	71.0	53.4	81.0	61.9	27.7	61.65	62.03	2	1
NE10609	40.0	58.4	56.8	52.6	39.7	74.7	58.1	26.6	50.86	52.41	44	37
Settler CL	70.5	64.9	52.1	45.4	45.5	81.6	69.9	24.9	56.85	54.90	12	17
NE10625	49.7	72.2	45.1	52.0	44.5	77.5	65.3	26.4	54.09	54.71	27	21
NE10628	53.7	65.4	49.7	56.0	45.3	64.6	57.9	23.5	52.01	51.77	40	40
NE10638	54.1	54.7	43.9	50.4	37.2	52.1	53.9	23.8	46.26	45.14	57	58
NE10683	50.4	59.8	66.0	58.2	42.5	74.3	58.8	24.0	54.25	54.80	26	19
NH09563	58.2	62.1	47.6	56.9	45.2	76.6	65.2	26.0	54.73	54.23	23	25
NH10665	61.3	69.9	55.1	68.5	51.0	70.9	70.0	24.6	58.91	58.57	8	7
NHH09655	57.1	62.2	50.8	54.7	50.1	69.7	65.7	26.5	54.60	54.24	24	24
NI04420	65.7	66.9	49.1	61.8	51.0	75.9	63.2	31.1	58.09	57.00	10	12
NI08708	63.1	59.2	46.6	52.2	44.9	75.0	60.2	25.3	53.31	51.91	34	39
NI09706	51.6	51.1	42.7	37.4	34.7	74.6	58.4	25.0	46.94	46.27	56	57
NI09709	69.7	62.3	47.8	55.6	47.6	72.4	69.5	28.2	56.64	54.77	14	20
NI09714W	66.3	64.1	53.1	67.0	46.3	62.4	61.1	26.2	55.81	54.31	17	22
NW03666	58.1	64.9	49.2	55.6	37.4	74.2	65.6	24.0	53.63	52.99	30	31
NW07505	55.3	71.0	54.3	61.4	39.1	72.1	62.5	27.8	55.44	55.46	18	13
NW09627	65.7	51.0	45.7	51.0	40.9	70.5	62.5	27.9	51.90	49.93	41	49
NW10401	60.4	70.1	50.7	59.1	43.4	73.8	64.7	25.2	55.93	55.29	16	15
NW10487	48.8	65.2	51.4	49.3	39.2	73.7	62.5	27.0	52.14	52.61	39	33
GOODSTREAK	43.9	50.6	46.6	45.3	38.1	47.8	53.0	24.5	43.73	43.70	59	59
SCOUT66	43.5	38.8	31.2	33.3	32.4	56.2	49.5	19.6	38.06	37.29	60	60
CHEYENNE	50.6	59.0	54.4	53.1	42.1	73.1	58.4	27.5	52.28	52.51	37	35
GRAND MEAN	55.71	64.12	51.2	54.46	43.38	70.9	61.15	25.73	53.33	52.99		

Data from 2012 to 2014 (three year average) from the Nebraska Intrastate Nursery for Grain Yield (bu/a) are presented below:

2012- 2014 Name	Mead Yield (bu/a)	Linc. Yield (bu/a)	C. Center Yield (bu/a)	N. Platte Yield (bu/a)	Sidney Yield (bu/a)	Alliance Yield (bu/a)	McCook Yield (bu/a)	**NE Avg. Yield (bu/a)**	**Rank**
Camelot	55.1	63.0	61.0	46.2	69.5	51.1	63.9	59.1	**18**
CHEYENN	42.0	48.6	50.7	43.5	56.5	39.8	61.0	48.3	**25**
GOODSTR	51.3	60.3	54.3	42.4	63.2	48.9	57.7	54.6	**24**
NE01481	58.7	67.5	58.4	52.1	68.5	41.8	66.5	59.0	**20**
NE05548	52.8	61.0	59.2	44.7	69.2	49.6	60.1	57.0	**22**
NE06430	55.7	66.2	58.1	49.9	64.8	47.0	68.8	59.4	**17**
Freeman	61.2	71.6	64.5	52.9	67.5	53.3	64.4	62.9	**3**
NE07486	58.7	66.0	62.8	50.8	68.9	46.8	69.3	61.0	**13**
NE07531	55.4	67.6	62.8	47.2	66.5	51.8	68.3	61.1	**12**
NE08499	59.3	67.1	62.6	46.1	66.8	48.4	66.7	60.5	**14**
NE09517	56.7	65.0	69.5	52.7	63.1	51.3	66.9	61.5	**9**
NE09521	60.4	63.7	65.2	55.0	68.2	49.2	64.0	61.1	**11**
NE10478	57.7	68.5	64.1	53.0	64.2	47.9	73.5	62.0	**6**
NE10507	61.9	73.5	66.0	53.0	70.0	44.7	70.4	63.2	**2**
NE10589	60.1	74.4	68.0	54.0	69.8	56.0	71.1	65.4	**1**
NE10683	58.1	74.4	64.7	51.5	65.9	48.0	68.9	62.5	**4**
NI04420	59.2	65.7	62.3	52.4	68.8	53.3	66.4	61.6	**8**
Robidoux	55.4	66.6	62.7	57.3	71.7	46.6	75.0	62.1	**5**
NW03666	57.5	61.4	65.3	45.3	67.7	45.2	70.4	60.0	**15**
NW07505	59.6	66.1	65.6	46.4	67.7	50.3	69.4	61.4	**10**
NW09627	47.1	58.8	58.7	44.1	67.3	53.7	64.1	56.8	**23**
Overland	61.2	67.7	65.4	52.0	68.6	50.2	66.3	61.9	**7**
SCOUT66	40.7	45.4	43.6	36.4	54.8	35.9	53.8	44.8	**26**
Settler CL	52.9	63.1	56.0	51.7	70.2	45.2	74.7	59.4	**16**
WESLEY	54.0	62.2	54.3	50.2	59.3	50.0	67.5	57.4	**21**
Mean	**55.7**	**64.6**	**61.0**	**49.2**	**66.3**	**48.2**	**66.8**	**59.4**	

As can be seen from the excellent three-year yields of released lines (Robidoux, Freeman, Settler CL, and Overland), our 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 are the NE10 lines (NE10589, NE10507, ND10683) which continue to do well in our and the State Variety Trials. As expected Cheyenne and Scout 66 were the lowest yielding lines, but again it was surprising that Scout 66 was lower yielding than Cheyenne. 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. Again Mead was low yielding due to disease and McCook had excellent yields with the remaining location being normal to good. In this nursery, Camelot and Goodstreak performed well, but Freeman was mediocre compared to the experimental lines. Camelot did particularly well. A number of lines show promise for continued testing toward new cultivar releases. The lines in the NTN have less performance history, so it is expected that some experimental lines will out-yield the checks, but most lines will have poorer performance. As in the NIN, there were low but positive correlations among the locations (the best being Clay Center and Sidney). The variation in one location could explain at most 38% of the variation in the other location. However, most locations explained less than 10% of the variation at the other locations. This result again indicated the value of extensive testing in NE.

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				

The data for the 2013 TRP:

2013 name	Mead Yield bu/a	Lincoln Yield bu/a	C. Center Yield bu/a	McCook Yield bu/a	Alliance Yield bu/a	NE. Avg. Yield bu/a	Rank	KS Yield bu/a	Rank
NE12406	67.7	71.0	73.2	48.0	51.0	62.18	44	55.2	55
NE12408	71.7	75.1	84.9	54.5	54.5	68.14	10	58.2	48
NE12409	72.9	72.1	76.5	48.5	59.7	65.94	29	60.3	36
NE12416	72.7	66.5	72.3	45.2	53.6	62.06	46	61.5	30
NE12417	75.9	75.9	69.2	48.0	62.9	66.38	24	56.1	54
NE12429	78.4	77.0	73.8	47.5	64.0	68.14	11	60.7	34
NE12430	77.1	77.7	82.2	51.5	64.3	70.56	2	60.1	42
NE12435	65.1	70.3	68.6	43.2	56.9	60.82	51	60.2	39
NE12438	74.4	73.1	86.4	48.5	69.4	70.36	4	65.3	10
NE12439	74.3	77.3	79.1	52.5	64.3	69.50	7	66.4	8
NE12443	78.0	79.0	84.6	47.6	56.6	69.16	8	69.2	2
NE12444	73.2	68.3	76.5	50.0	65.9	66.78	21	58.1	49
NE12450	65.0	87.3	76.1	46.5	63.1	67.60	14	61.9	27
NE12456	60.3	71.2	72.7	41.7	56.7	60.52	55	54.3	56
Camelot	73.0	70.6	78.9	48.9	64.7	67.22	18	60.7	34
NE12459	71.7	72.8	72.4	46.6	57.9	64.28	36	62.4	20
NE12461	76.6	82.1	79.1	47.5	54.9	68.04	12	68.5	4
NE12464	75.9	75.6	81.3	44.9	66.4	68.82	9	64.5	12
NE12467	64.3	74.4	70.9	33.8	56.3	59.94	56	54.0	57
NE12480	62.4	60.8	77.9	34.9	61.6	59.52	59	61.1	32
NE12482	68.6	67.2	70.9	34.9	64.2	61.16	50	62.4	20
NE12483V	70.3	63.2	78.2	49.5	69.6	66.16	26	72.9	1
NE12486	70.5	71.3	63.5	37.6	60.5	60.68	53	61.8	28
NE12488	68.9	78.3	75.7	46.4	60.9	66.04	27	60.2	39
NE12503	70.7	78.2	76.4	44.2	66.5	67.20	19	62.4	20
NE12509	69.7	69.4	70.9	49.6	51.0	62.12	45	62.7	19
NE12510	73.4	76.8	78.2	46.7	53.9	65.80	30	65.1	11
NE12518	75.2	70.1	79.6	51.8	59.6	67.26	17	62.4	20
NE12521	63.5	63.1	77.0	42.9	56.4	60.58	54	51.8	59
GOODSTREAK	72.3	61.6	71.1	47.5	61.9	62.88	42	62.1	25
NE12524	75.8	73.4	77.2	55.3	67.3	69.80	6	57.7	50
NE12538	66.7	69.7	67.2	45.3	54.8	60.74	52	64.4	13
NE12539	63.3	69.0	64.6	40.0	55.4	58.46	60	51.5	60
NE12550	69.8	75.4	75.2	39.8	58.2	63.68	38	67.1	6
NE12561	71.7	76.1	80.1	45.2	62.1	67.04	20	59.7	45
NE12563	69.3	73.5	81.5	42.4	57.4	64.82	35	65.5	9
NE12568	73.6	67.6	65.3	42.3	59.5	61.66	48	61.0	33
NE12571	75.0	75.5	76.1	53.7	53.0	66.66	22	66.9	7
NE12578	75.8	72.1	75.7	43.3	52.1	63.80	37	64.4	13
NE12580	71.8	76.1	79.3	56.1	54.3	67.52	15	62.3	24
NE12582	67.6	73.2	74.0	41.9	56.1	62.56	43	53.9	58
NE12583	64.0	71.2	75.2	44.3	55.5	62.04	47	62.0	26
NE12585	68.9	71.3	78.3	46.3	59.6	64.88	33	58.5	47
NE12589	78.5	77.1	86.4	45.0	62.7	69.94	5	67.5	5
OVERLAND	73.6	78.3	84.4	42.5	53.8	66.52	23	59.9	44
NE12595	64.8	61.6	78.3	36.4	58.2	59.86	58	61.8	28

NE12596	64.1	64.1	72.2	39.3	60.0	59.94	56	58.7	46
NE12598	70.1	72.4	76.5	41.7	55.8	63.30	41	56.2	53
NE12630	67.4	65.7	78.6	52.8	65.3	65.96	28	57.7	50
NE12634	70.9	69.4	77.2	50.6	57.2	65.06	32	60.3	36
NE12637	68.4	74.8	80.1	46.8	57.8	65.58	31	63.9	15
NE12639	62.4	65.8	72.9	45.7	60.0	61.36	49	63.4	16
NE12659	74.8	72.2	75.1	45.8	56.5	64.88	34	60.2	39
NE12662	78.8	78.6	81.9	50.9	62.5	70.54	3	63.1	17
NE12668	72.4	74.5	72.2	49.7	63.0	66.36	25	60.3	36
NE12675	69.2	73.9	72.8	44.0	57.2	63.42	40	57.1	52
NE12685	73.7	70.7	73.1	45.9	55.0	63.68	38	61.5	30
NE12686	73.3	75.4	89.5	57.2	61.6	71.40	1	68.8	3
NE12689	72.7	74.1	80.9	47.3	63.2	67.64	13	60.1	42
NH12615	73.2	70.7	84.0	47.2	61.7	67.36	16	63.0	18
MEAN	**70.92**	**72.35**	**76.39**	**46.09**	**59.43**			61.35	
LSD	**8.18**	**7.48**	**9.19**	**8.38**	**9.18**			**5.98**	
CV	**5.96**	**6.37**	**7.44**	**8.89**	**9.52**			**6.01**	
Heritability	**0.99**	**0.99**	**0.7**	**0.99**	**0.97**			**0.99**	

The data for the 2012 TRP:

2012 name	KS (bu/a)	Mead (bu/a)	Linc. (bu/a)	Clay C. (bu/a)	N. Platte (bu/a)	McCoo (bu/a)	Sid (bu/a)	Allian. (bu/a)	Mean (bu/a)	Rank	Flower date
Camelot	41.3	58.0	48.2	50.7	37.7	63.2	63.7	46.0	51.1	52	**125.7**
GOODSTREAK	36.4	49.4	43.2	39.2	31.7	51.5	57.1	48.8	44.7	60	**125.4**
Overland	47.8	76.6	52.0	64.5	42.7	75.4	65.6	51.6	59.5	6	**129.0**
NE11415	66.9	51.7	41.9	51.9	43.4	82.6	63.1	49.6	56.4	16	**117.7**
NE11423	64.0	53.3	42.1	46.4	39.5	66.4	58.4	45.4	51.9	46	**123.1**
NE11426	45.4	65.2	49.7	51.9	41.9	72.4	57.6	47.1	53.9	30	**117.6**
NE11440	61.2	60.7	39.4	55.2	37.0	64.7	60.8	49.2	53.5	36	**122.0**
NE11443	51.9	59.2	46.2	51.4	38.3	60.1	61.4	38.8	50.9	54	**117.6**
NE11455	64.0	63.5	45.4	46.2	39.4	82.2	65.8	40.9	55.9	20	**119.3**
NE11461	60.9	54.8	52.1	47.8	43.3	66.2	62.9	47.7	54.5	25	**122.0**
NE11464	52.7	55.3	49.5	47.1	38.3	77.9	54.2	45.9	52.6	42	**119.7**
NE11470	58.9	55.2	46.5	55.0	44.5	72.2	63.4	51.2	55.9	21	**117.7**
NE11472	62.1	60.6	50.2	58.6	44.1	78.6	60.4	47.2	57.7	12	**119.7**
NE11480	55.1	56.5	47.4	45.7	39.2	68.7	59.6	43.3	51.9	46	**121.5**
NE11482	48.9	59.3	47.7	53.2	43.7	72.7	66.6	52.2	55.5	22	**126.3**
NH11489	60.4	57.7	50.3	55.4	43.7	88.2	64.8	47.1	58.5	9	**123.1**
NH11490	48.2	63.6	49.1	52.5	41.6	75.2	64.6	44.7	54.9	24	**123.7**
NE11499	62.4	67.5	52.4	54.8	40.8	77.9	65.7	46.1	58.5	8	**121.3**
NW11510	67.0	51.1	38.8	49.7	41.6	85.9	57.6	38.4	53.8	32	**117.7**
NW11511	68.1	53.1	48.1	55.3	50.3	88.8	59.1	41.4	58.0	11	**116.1**
NW11514	57.6	61.7	38.0	50.6	40.3	75.0	62.8	45.2	53.9	31	**119.1**
NE11522	52.6	64.1	44.6	48.3	36.9	63.9	55.0	45.1	51.3	49	**121.6**
NE11527	52.2	64.6	51.5	51.4	40.0	69.0	64.3	47.1	55.0	23	**124.4**
NE11530	45.9	63.7	52.6	50.3	35.8	60.8	56.3	49.3	51.8	48	**124.1**
NE11536	41.2	65.9	49.1	61.0	48.6	69.5	65.2	50.6	56.4	16	**127.7**
NE11543	41.2	61.1	50.1	40.8	38.6	67.9	59.0	50.8	51.2	50	**126.7**

NE11560	69.3	60.8	56.8	59.6	53.5	83.3	70.0	48.4	62.7	1	**120.6**
NH11563	56.6	64.4	52.0	51.4	51.1	77.5	65.9	42.6	57.7	13	**126.0**
NH11565	62.6	63.7	57.9	59.5	44.3	85.8	60.0	51.1	60.6	2	**122.7**
NHH11569	56.3	59.0	45.3	54.3	39.6	63.4	58.2	44.9	52.6	41	**122.4**
NE11581	51.7	61.9	48.2	44.9	39.2	64.1	59.8	53.3	52.9	39	**122.0**
NW11588	34.3	62.1	55.3	52.4	41.4	65.4	60.7	50.4	52.8	40	**126.3**
NW11589	33.0	54.1	48.7	45.7	31.4	53.8	57.4	41.2	45.7	59	**124.7**
NW11590	58.8	67.4	54.7	60.0	48.1	81.9	64.6	48.3	60.5	3	**121.9**
NW11593	49.0	55.5	40.9	47.5	39.4	71.9	59.3	45.9	51.2	51	**119.3**
NW11598	61.2	57.2	53.5	57.4	47.0	78.6	68.6	43.3	58.4	10	**123.7**
NE11607	45.9	75.0	59.9	71.6	46.9	73.4	53.9	51.6	59.8	5	**129.4**
NE11608	40.7	65.7	54.3	51.4	40.5	65.9	56.6	50.0	53.1	38	**129.3**
NE11610	32.1	62.0	51.0	57.1	43.9	67.1	62.7	52.2	53.5	37	**127.7**
NE11612	35.7	59.9	56.0	62.9	43.5	64.6	59.8	46.9	53.7	33	**130.0**
NE11613	39.6	59.3	50.7	60.6	41.4	65.0	59.0	43.5	52.4	43	**125.7**
NH11631	44.5	71.0	58.9	47.9	39.8	84.6	59.2	41.5	55.9	19	**129.3**
NHH11638	34.6	71.3	59.6	54.4	47.9	90.0	57.4	46.1	57.7	14	**127.6**
NHH11639	34.6	65.9	56.7	53.6	44.9	83.2	64.8	43.9	56.0	18	**128.9**
NE11642	37.6	66.1	47.2	52.0	37.0	59.6	56.5	51.5	50.9	53	**130.0**
NE11643	40.0	62.5	47.2	67.3	36.9	59.0	59.0	46.5	52.3	44	**129.6**
NW11645	43.8	63.4	52.5	53.8	33.0	66.3	50.3	53.9	52.1	45	**129.0**
NE11652	45.3	69.1	51.1	59.6	39.9	59.6	60.4	49.6	54.3	26	**129.6**
NE11653	27.3	74.4	56.0	60.1	36.7	67.4	62.6	48.9	54.2	29	**128.7**
NE11654	46.6	68.0	63.1	64.9	43.2	71.9	65.4	51.6	59.3	7	**129.2**
NE11655	31.9	65.2	51.9	47.1	38.3	67.9	55.7	44.8	50.4	55	**129.9**
NH11663	37.1	71.3	56.6	50.5	35.4	73.8	63.1	46.4	54.3	27	**130.6**
NH11664	40.0	75.1	52.6	49.9	38.4	72.7	59.5	40.5	53.6	34	**130.4**
NH11668	41.3	73.6	57.9	52.3	39.4	78.8	61.6	47.4	56.5	15	**129.4**
NE11684	32.1	69.6	55.1	64.1	43.2	67.7	54.2	42.6	53.6	35	**130.9**
NE11688	41.6	73.7	61.9	73.3	49.9	70.1	65.4	46.7	60.3	4	**128.3**
NE11690	27.8	60.2	49.1	43.7	33.9	69.1	59.9	42.2	48.2	58	**128.6**
NH11691	35.1	54.4	54.1	45.8	40.1	79.3	46.1	46.3	50.2	56	**130.6**
NW11696	33.4	61.9	46.3	47.4	36.2	63.5	59.0	47.0	49.3	57	**127.6**
NE11697	60.7	56.0	42.8	50.2	44.8	62.7	62.7	54.3	54.3	27	**120.0**
Mean	47.9	62.6	50.5	53.5	41.2	71.4	60.6	46.9	54.3		**124.8**

6. Regional Nurseries

In 2014, 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 progress has been made.

7. Multiple-Location Observation Nursery

All seven locations in Nebraska (Lincoln, Mead, Clay Center, North Platte, McCook, Sidney, and Alliance) were planted and harvested. To better estimate the yield at key locations, two replications were planted at Lincoln, North Platte, and Alliance. An additional location was collaboratively planted and harvested in Kansas. The Kansas site was very high yielding due to it being treated with fungicides and given very high fertility–to maximize grain yield. The eight locations (seven in NE and one in KS) were used for selection. 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 fourth 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). We will continue to do to this and have secured funding to do this on earlier generation material. One novel twist thatDr. Poland added was we are now reanalyzing the GBS data over years, thus creating a "training" population and tying all our datasets together. Genotyping has many missing data points, but this approach has really helped us understand our materials. The 2014 data were quite interesting because were we able to look at phenotypic data (our traditional selection protocol), as well as the current year estimated breeding values (EBVs=EBV1) and those developed over four years (= EBV4). By comparing and selecting on phenotypic values, EBV1 and EBV4, our hope is not to lose a promising line. In theory, EBV4 and phenotypic selection should be the best. One change that we will add is a stratified selection, where we will ensure that the highest-yielding tall wheat lines, disease resistant wheat lines, etc., are retained. By predominantly selecting on grain yield, plant breeders tend to select semi-dwarf lines. The top ten lines out of 270 experimental lines are below:

2014	Mead	Linc	C.Cent.	N. Platte	McCook	Sidney	Alliance	KS	Average	Rank
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	
Names3	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)	(bu/a)	
NE14658	47.5	74.7	65.5	47.6	88.6	68.1	70.4	71.5	66.7	1
NE14537	49.3	74.8	58.9	50.7	97.4	73.8	64.3	64.3	66.7	1
NE14434	50.2	78.6	61.5	54.7	92.1	72.9	64.7	57.3	66.5	3
NE14606	39.3	72.1	59.9	52.7	97	82	61.1	66.8	66.4	4
NE14531	43.9	80.4	62.6	53.9	81.1	84	63.8	58.4	66	5
NE14696	34.4	79.5	68.1	40.6	91.5	72.6	69.5	70.6	65.8	6
NE14607	46.6	68.3	65	45.6	97.2	76.8	66.8	59	65.7	7
NE14401	41.6	63.6	59.4	51.1	73.3	78.9	71.7	84.3	65.5	8
NE14656	42.7	70.7	62.9	53.5	106.3	56.2	68.3	59.7	65	9
NE14647	45.8	65.3	60.6	54.1	101.8	68.9	67	55.4	64.9	10

Camelot ranked 26 in this trial. Freeman ranked 50. Goodstreak ranked 88.

8. Early Generation Nurseries

a. Single-plot Observation Nursery

Fourteen hundred and eighty-six lines were evaluated at Lincoln in 2014. Of the 1486 lines and checks, 1268 were red and 218 were white seeded or mixed red and white seeded. The lines included 71 one and two-gene herbicide tolerant lines (mainly two gene), 193 possible FHB tolerant lines, 92 possible lines with WSMV tolerance, and 83 Hessian fly-tolerant lines. In addition, 68 Clearfield observation plots were planted. All 1554 lines were harvested, to get better information than through visual selection. Those lines with acceptable yield were then test weighed and if the test weight was good, their protein was measured. Five hundred lines with good yield, test weight, and protein content were sent to the Seed Quality Laboratory for micro-quality evaluations. Two hundred seventy lines were advanced. We will try to be more selective in this nursery so that harvesting all the plots will be very efficient.

b. Headrow Nursery

In 2013-14, 48,100 (of which 4,000 were herbicide-tolerant) headrows were planted at Lincoln. In general, the headrow nursery was a little larger than normal. We harvested more than1800 lines which were planted in 2014-2015. Fifteen hundred forty-four were selected for advancement. From the imi-headrows, 377 were selected for advancement. The main selection criteria for discarding headrows was black point or poor seed quality. Of the red and white wheat lines, 238 were sent to Scottsbluff for planting in our irrigated observation nursery.

c. F_3 bulk hybrids

The F_3 bulk hybrid nursery contained 1108 red, red and white segregating, or white seeded bulks. In addition, we planted 54 herbicide-tolerant bulks (planted at Lincoln). 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. The number of F_3 bulks is high and we intend to reduce it in future. Over 50,600 head rows were selected for fall planting in 2014 and were planted on time. In general, their emergence and stands were very good in the fall, but a heavy rain right after part of the field was planted led to washing and plot mixing. The project goal remains to have sufficiently good segregating F_3 material to select about 40 - 45,000 headrows.

d. F_2 bulk hybrids

The F_2 bulk hybrid nursery contained 1063 bulks and check plots that were planted at Mead. Fifty-eight F_2 bulks with two genes for herbicide resistance were planted at Lincoln for selection. The bulks generally survived the winter, but some were winterkilled (those involving winter tender parents). We continued not sharing our bulk populations this year as the new Wheat Workers Material Transfer Agreement (WWMTA) requires prior approval of bulk sharing for any subsequent segregating generation. There is no approved bulk sharing form attached to the WWMTA and the paperwork will continue to a major hurdle. As such, the path of least resistance is simply to not share bulks except with those who we have pre-existing bulk-sharing agreements (e.g. CIMMYT). No bulk is shared that includes parental germplasm that requires approval. While this curtailment of bulk sharing is unfortunate and in many ways a waste of resources (groups making the same crosses or not having access to crosses they wished they had made), the alternative concern is that some programs prefer not to share their segregating germplasm with other institutions and businesses.

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

In 2014, one new triticale line (NT06427) was recommended for release. Also, we selected additional lines for increase as possible replacements or to complement NE426GT, NE422T, and NE441T (a licensed line) which continue to perform well. Because triticale is a small market crop, we are carefully deciding how best to release new triticale cultivars so as to not cause inventory problems with the previously released cultivars. Our current thoughts are that we will most likely partner with a triticale seed supplier to merchandise our next release. We also expanded our collaborative testing area into New York, Kansas, and New Mexico.

NT06427 is a winter triticale (x Triticosecale Wittmack) cultivar developed cooperatively by the

Nebraska Agricultural Experiment Station and the USDA-ARS and released in 2014 by the developing institutions. It was released primarily for its awnletted spike, good grain yield, and good forage yield when compared to currently grown triticale cultivars. It is adapted to rainfed triticale production systems in Nebraska and in adjacent states. NT06427 will be licensed with the expectation that the name will emphasize the short awns on the spike as it is considered a valuable trait in forage small grains because feeding small-grains hay with long awns is a mouth irritant and affects hay consumption.

NT06427 was selected from the cross NE96T431/Titan where the pedigree of NE96T431 is TSW250783//GWT88-12/LAD285. The cross was made in 2000. The F_1 generation was grown in the greenhouse in 2001 and the F_2 to F_3 generations were advanced using the bulk breeding method in the field at Lincoln from 2002 to 2003. In 2004, single F_3-derived F_4 rows were planted for selection at Lincoln. There was no further selection thereafter. The $F_{3:5}$ was evaluated as a single four-row plot at Lincoln in 2005. NT06427 was identified in 2006 as the experimental lineand selected for further testing in multi-location trials (Lincoln, Mead, and Sydney). Thereafter it was tested in multi-location replicated trials at the same three Nebraska locations.

NT06427 was evaluated in Nebraska-replicated yield nurseries starting in 2007 for grain yield. In 2008, limited forage trials began. In the Nebraska Triticale Grain and Forage Nurseries (2008 to 2013, Table 1), NT06427 was compared to previous released cultivars NE422T, and NE426GT. NT06427 had significantly higher grain yield (3718 lba/a) than NE422T and was not significantly lower in grain yield than NE426GT. For forage yield (cut approximately 10 days after flowering), NT06427 was not significantly lower yielding (8112 lbs/a) than NE422T or NE426GT.

Other measurements of performance from comparison trials indicate that NT06427 is medium early in maturity (flowering 139 days after Dec. 31), most similar to NE426GT and 4 days earlier than NE422T, which is considered maturity late-maturing line. NT06427 is mid-tall triticale slightly shorter than NE426GT and significantly shorter than NT4422GT. In the two trials where winter injury occurred, NT06427 was not significantly different (78% winter survival) from NE422T and NE426GT, hence, these lines would be considered comparable to the currently grown triticale cultivars. Historically winter triticale is not as winter hardy as the more winter hardy winter wheat cultivars, but in most years and locations in Nebraska, winter injury is minor.

Triticale has few diseases in Nebraska and there are no regional nurseries, so there is little disease or insect data to report. NT06427 was tested in Kenya in 2012 and scored as 1 (on a 0 to 100 scale with 0 being low) for stem rust (caused by *Puccinia graminis Pers.: Pers. f. sp. tritici* Eriks & E. Henn.) using the races common to Kenya (TTKSK and its derivatives). In the same trial, popular wheat (*Triticum aestivum* L.) cultivars (Jagger, 50-60; Scout 66 known to contain Sr_2, 55/20; and Overland believed to contain Sr_{tmp}, 10) scored higher. NT06427 was also scored in Kenya for field races of stripe rust (caused by *P. striiformis* Westendorp f. sp. t*ritici*) and scored as moderately resistant. In Nebraska, when leaf (caused by *P. triticina* Eriks,) stripe, or stem rust were present on wheat, NT06427 would be considered as resistant. In years of high infection of ergot (caused by Claviceps purpurea (Fr.) Tul.), NT06427 has had very low infections. During its selection, lines with ergot are routinely discarded.

In positioning NT06427, based on performance data to date, it should be well adapted to most rainfed wheat production systems in Nebraska and in adjacent areas of the Great Plains where grain or forage triticale are grown. In limited testing outside of Nebraska, NT06427 is competitive to other Nebraska developed cultivars. NT06427 has not been tested under irrigation.

NT06427 is an awnletted, ivory-glumed cultivar. The coleoptile color is white. Its field appearance is most similar to NT0426GT, but can be easily separated from NE426GT because NE426GT is awned. The flag leaf is recurved and twisted at the boot stage. The foliage is green with a waxy bloom on the leaf sheath. The auricle is colorless or white and lightly pubescent. The neck is pubescent (hairy). The head is oblong and mid-dense. The glume is pubescent, white, long, and the glume shoulder is wanting. The beak has an acuminate tip. Kernels are amber colored, elliptical in shape, moderately wrinkled, with a large and long brush. NT06427 was licensed to Ehmke Seeds and is expected to be marketed under the name Short Beard Thunder.

Development team: P. S. Baenziger (breeder-inventor), K. Vogel, S. Wegulo, T. Regassa, D. Santra, and G. Hein.

In 2014, six lines (including NE426GT and NE422T) were recommended for increase or re-increasing. It appears that NE422T has 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 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

These trial results indicate that: 1. triticale produces more biomass and grain yield generally than wheat; 2. there is considerable GxE for forage yield; and 3. it very difficult to couple grain yield with forage yield. The comparison likely was 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, NT09423 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 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 2013 forage data from Sidney NE (thanks to Dr. Dipak Santra) are:

name	foragedry	Rank
	lbs/a Dry	
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 2013 grain yields from Nebraska and a collaborative site in Kansas are:

	Llincoln	Llincoln	Lincoln	Llincoln	Mead	NEB.	Rank	Kansas	NE + KS	Rank
2013	Height	Heading Date	Grain Yld	Test Weight	Grain Yld	Avg. Yield		Grain Yld	Avg. Yield	
name	(in)	Julian	Lbs/a	Lbs/bu	Lbs/a	Lbs/a		Lbs/a		
NE422T	60.3	150	2622	50.09	3826	3224.0	23	2512	2986.5	23
NE426GT	48.7	148	2482	47.16	3180	2831.0	29	2810	2824.0	29
NT01451	49.0	149	2641	47.30	3482	3061.5	26	2474	2865.7	26
NT05421	57.3	149	3550	50.89	4620	4085.0	7	2964	3711.5	7
NT05429	48.7	147	3870	48.85	3692	3781.0	13	2467	3342.9	13
NT06422	51.7	148	4186	47.49	3854	4020.0	9	2691	3577.1	9
NT06427	49.7	148	3005	46.86	3566	3285.5	22	2447	3006.1	22
NT07403	48.0	146	4291	52.14	4652	4471.5	3	2424	3789.2	3
NT09404	53.3	148	3116	47.82	3689	3402.5	18	2475	3093.4	18
NT09423	50.0	149	3768	49.88	4298	4033.0	8	2586	3550.7	8
OVERLAND	42.0	150	2867	58.71	3859	3363.0	19	2527	3084.4	19
NT10417	52.3	148	3429	45.53	3960	3694.5	16	2275	3221.2	16
NT10429	55.7	149	3274	51.57	5055	4164.5	6	2124	3484.2	6
NT10441	48.7	149	3532	48.30	3964	3748.0	14	1880	3125.3	14
NT11404	53.0	148	3411	47.16	3195	3303.0	21	2403	3003.0	21
NT11406	48.7	149	3342	46.58	3929	3635.5	17	1712	2994.4	17
NT11410	51.0	147	3763	47.34	4131	3947.0	10	1609	3167.8	10
NT11428	55.3	149	3708	49.03	3996	3852.0	11	1966	3223.4	11
NT11444	56.3	150	3276	48.91	4191	3733.5	15	3170	3545.7	15
NT12403	50.0	147	4002	53.28	4902	4452.0	4	2515	3806.3	4
NT12404	49.3	146	4230	49.95	4812	4521.0	2	2602	3881.4	2
NT12406	50.7	147	3728	50.36	3964	3846.0	12	1985	3225.7	12
NT12411	46.0	148	2275	46.20	3683	2979.0	28	2760	2906.0	28
NT12412	52.3	149	2784	48.82	3875	3329.5	20	2532	3063.6	20

The 2013 forage yields from Nebraska (thanks to Dr. Ken Vogel, USDA-ARS) and collaborative sites in Kansas and Oklahoma are:

	Mead	KS	OK		Rank
2013	Forage	Forage	Forage	Aver	Forage

	YLD	YLD	YLD	For	
name	lbs/a	lbs/a	lbs/a	lbs/a	
NE422T	8502	6975	2859	6111.8	15
NE426GT	8700	7827	4084	6870.3	2
NT01451	8385	8669	3403	6819.1	3
NT05421	8944	7502	3403	6616.4	7
NT05429	8864	6401	3539	6267.9	11
NT06422	8725	8803	4220	7249.2	1
NT06427	8597	6517	3539	6217.6	13
NT07403	8528	4874	3948	5783.3	21
NT09404	8154	5490	4220	5954.6	17
NT09423	7955	5711	4084	5916.4	18
OVERLAND	7156	3402	2723	4427.0	24
NT10417	8239	6874	3675	6262.8	12
NT10429	8916	6097	3812	6274.9	10
NT10441	8894	5659	3948	6166.8	14
NT11404	8282	7010	3948	6413.3	9
NT11406	7883	5674	3403	5653.5	23
NT11410	8859	7306	3403	6522.7	8
NT11428	8745	5045	3812	5867.0	19
NT11444	8652	5345	3403	5800.0	20
NT12403	8706	5679	3812	6065.4	16
NT12404	8214	5435	3539	5729.5	22
NT12406	8885	6642	4356	6627.5	6
NT12411	7969	8787	3675	6810.5	4
NT12412	8608	7666	3812	6695.3	5

The forage results from New York in 2013 are:

	T/A
Variety	DM
NT05429	3.56
NT06422	4.00
NT07403	2.88
NT0422T	3.61

The 2013 forage data from Sidney NE (thanks to Dr. Dipak Santra) are:

2013	Height	Forage	Rank	Dry Matter
Name	in	DM Lbs/a		%
NE422T	52.4	4885	3	0.325
NT01451	39.5	4467	8	0.337
NT05421	47.3	5184	1	0.358
NT05429	41.3	4547	5	0.34
NT06422	41.0	4294	9	0.336
NT06427	40.3	5156	2	0.357
NT07403	42.5	4494	7	0.358
NT09404	42.0	4873	4	0.347
NT10429	46.0	4514	6	0.345
NT10441	40.0	4093	10	0.342
Avearge	43.21	4650.5		0.344
LSD	7.0	535.8		0.019
CV	11.1	7.9		3.9
Heritability	0.33	0.41		0.29

The 2012 forage results from Wisconsin were:

		Seeding Rate		Yield	
Variety		(seeds/packet)		Kg/ha	Rank
NE03T416		4400		4954	5
NT01451		4400		4813	7
NT05421		4400		5135	4
NT05429		4400		5215	2
NT06422		4400		5465	1
NT06427		4400		4862	6
NT07403		4400		5157	3
815		4400		4558	8

815 is a local check and it is clear that our lines can compete with the local lines in Wisconsin based on this year's data.

The forage data from North Platte in 2012 are (thanks to Dr. Jerry Volesky):

Triticale Plots 2012	
	2012
Entry	**- - - Tons/acre - - -**
Wheat Border	5.07
1010 Triticale	5.39
NT05429	5.97

NE03T416	6.08
Syn Exp	6.20
NT07403	6.21
NT05421	6.23
NT06427	6.23
NT06422	6.39
TriCal 348	6.58
ATR-626	6.59
NE422T	7.17
NT01451	7.29

Again our lines did very well compared to the local check 1010 Triticale.

The results for the 2012 forage trial at Sidney were (thanks to Dr. Dipak Santra):

name	Yield	NDF	ADF	Prot	RFV	TDN
	lbs/a					
GOODSTREAK	6312	54.6	35.6	11.8	104	62
NE422T	6193	52.15	32.8	11.4	113	65.2
NE426GT	6212	53.75	35.6	10.75	106	62
NT01451	6786	53.95	34.2	12.1	108	63.6
NT05421	6863	54.4	34.15	11.15	107	63.6
NT06427	6793	56.8	36.4	11.5	100	61.1
NT07403	6200	54.8	34.55	12.05	105	63.2
NT09404	7114	54.9	35.15	11.4	104	62.5
NT09423	6905	57.2	37.85	11.6	97	59.4
NT10441	7065	56.2	36.7	11.3	100	60.8
NT10418	7016	56.85	36.15	11.5	100	61.3
NT10429	6319	55.3	35.3	11.35	103	62.3
GRAND MEAN	6648.19	55.08	35.37	11.49	103.63	62.23
LSD	1240.4	3.33	2.71	1.52	9.04	3.06

The results for the 2012 forage triticale trial at Mead, NE are (thanks to Dr. Ken Vogel):

Name	Yield	IVDMD	NDF	ADF	ADL	NITROGEN	DM %
	Lbs/a						
OVERLAND	10108	70.22	54.45	31.65	4.39	1.55	0.4
NE422T	12454	68.6	61.44	36.89	5.04	1.36	0.34
NE426GT	12951	70.48	56.05	32.19	4.38	1.47	0.34
NT01451	12521	69.72	58.58	34.56	4.77	1.48	0.33
NE03T416	11809	70.99	54.77	32.69	4.37	1.38	0.35
NT05421	12638	68.59	58.61	34.62	4.81	1.39	0.35
NT05429	11780	70.88	52.51	31.36	4.16	1.39	0.37
NT06422	11863	70.46	53.42	31.72	4.29	1.39	0.38

NT06423	12090	68.26	57.81	34.59	4.8	1.4	0.36
NT06427	12372	69.58	56.72	33.41	4.51	1.44	0.35
NT07403	13075	71.14	52.02	30.42	4.02	1.44	0.4
NT08414	13083	69.22	56.13	33.59	4.48	1.37	0.33
NT08425	12359	70.43	54.79	32.07	4.31	1.47	0.35
NT09404	12892	70.1	56.79	33.36	4.64	1.57	0.34
NT09423	11698	69.67	58.38	34.4	4.63	1.49	0.33
NT10444	12955	70.93	54.49	32.26	4.4	1.44	0.35
NT10441	11509	69.83	55.79	32.37	4.52	1.41	0.35
NT10417	12236	70.32	55.5	33.11	4.44	1.31	0.36
NT10418	12670	69.1	56.56	33.28	4.41	1.37	0.36
NT10429	11199	68.29	59.09	34.93	4.64	1.45	0.36
NT10443	11951	68.24	61.18	37.01	4.87	1.36	0.35
NT11404	12088	70.02	56.46	33.3	4.54	1.5	0.34
NT11406	12924	69.98	57.33	33.68	4.59	1.38	0.33
NT11408	13906	69.67	55.87	33.2	4.51	1.39	0.35
NT11410	12771	70.1	55.73	33.53	4.47	1.36	0.34
NT11419	12596	68.6	57.78	34.15	4.74	1.27	0.35
NT11428	13220	68.73	59.29	34.97	4.62	1.42	0.34
NT11430	13203	70.49	55.66	32.76	4.39	1.32	0.35
NT11438	12609	69.05	57.14	34.3	4.6	1.32	0.35
NT11444	13567	68.18	59.06	35	4.54	1.32	0.35
GRAND MEAN	12437	69.66	56.65	33.51	4.53	1.41	0.35
LSD	1588	1.63	2.54	1.62	0.31	0.19	0.02
CV	9.05	1.65	3.18	3.42	4.9	9.75	4.07

The results for the 2012 grain triticale trials are:

	Grain	Grain	Grain	**State**	**Rank**	**State**	**State**
	Yield	Yield	Yield	**Avg Yield**		**Avg. Hdate**	**Avg. Height**
	(lbs/a)	(lbs/a)	(lbs/a)	**lbs/a**		**(d after**	**(in)**
name	Linc.	Mead	Sidney			**Jan.1)**	
Overland	3100	4127	3139	**3455**	**25**	**129.7**	**38.0**
NE422T	3965	3732	1868	**3188**	**28**	**131.0**	**55.0**
NE426GT	4497	4593	3213	**4101**	**4**	**128.2**	**46.3**
NT01451	4312	4152	2785	**3750**	**20**	**129.5**	**44.5**
NE03T416	4520	4327	2708	**3852**	**14**	**122.2**	**46.8**
NT05421	4380	4680	2569	**3876**	**12**	**124.8**	**49.9**
NT05429	4087	4392	2967	**3815**	**17**	**121.2**	**43.4**
NT06422	4421	4794	3061	**4092**	**6**	**121.7**	**48.2**
NT06423	4266	4045	3235	**3849**	**16**	**128.2**	**48.9**
NT06427	4161	3880	2781	**3607**	**23**	**125.2**	**44.5**
NT07403	4482	4200	3372	**4018**	**9**	**119.4**	**45.0**
NT08414	3886	4369	2944	**3733**	**21**	**127.5**	**44.4**

NT08425	4392	4222	3106	**3907**	**11**	**128.0**	**47.2**
NT09404	4334	4392	2865	**3864**	**13**	**129.2**	**48.4**
NT09423	4826	5060	3183	**4356**	**1**	**129.9**	**44.6**
NT10444	4191	3960	3118	**3756**	**18**	**125.5**	**45.0**
NT10441	4516	4551	3086	**4051**	**7**	**129.0**	**45.3**
NT10417	4597	4964	2993	**4185**	**3**	**125.5**	**46.8**
NT10418	4128	3765	2319	**3404**	**27**	**124.0**	**51.3**
NT10429	4154	3695	2377	**3409**	**26**	**129.9**	**52.9**
NT10443	3760	3143	1678	**2860**	**30**	**131.4**	**50.8**
NT11404	4517	4586	2989	**4031**	**8**	**126.5**	**44.7**
NT11406	4747	4956	3075	**4259**	**2**	**129.4**	**46.6**
NT11408	4361	4472	2714	**3849**	**15**	**125.9**	**51.4**
NT11410	4276	4643	2960	**3960**	**10**	**126.5**	**44.3**
NT11419	4354	3575	2926	**3618**	**22**	**129.3**	**50.2**
NT11428	5144	4492	2662	**4099**	**5**	**129.2**	**50.9**
NT11430	4008	4328	2280	**3539**	**24**	**127.2**	**49.7**
NT11438	3595	3901	1544	**3013**	**29**	**129.0**	**52.1**
NT11444	4638	4244	2371	**3751**	**19**	**130.7**	**52.0**
LSD	865.19	678.46	538.78				
CV	10.23	9.64	11.93				
MEAN	**4287**	**4275**	**2763**	**3775**		127.1	47.6

The three-year (2012-2014) grain-yield data summary for locations where we were able to harvest trials is presented below:

2012-2014 name	Hdate (d after Jan.1) Linc.	Grain Yield (lbs/a) Linc.	Height (in) Linc.	Hdate (d after Jan.1) Mead	Grain Yield (lbs/a) Mead	Height (in) Mead	Grain Yield (lbs/a) Sidney	Height (in) Sidney	**State Avg Yield lbs/a**	**Rank**	**State Avg. Hdate (d after Jan.1)**	**State Avg. Heigh (in)**
NE422T	139.0	3143.7	58.2	134.0	3197.3	57.4	2502.0	51.6	3003.4	**13**	131.0	56.0
NE426GT	135.9	3189.0	49.1	132.7	3322.7	46.8	3356.0	42.6	3280.9	**12**	128.2	45.5
NT01451	137.9	3381.0	47.3	132.3	3334.0	47.1	3338.0	40.8	3352.6	**10**	129.5	44.3
NT05421	136.2	3857.0	54.6	126.3	4115.7	51.7	3199.0	46.2	3789.5	**3**	124.8	50.9
NT06422	132.9	4054.7	49.9	125.7	3708.0	52.5	3431.5	44.1	3768.9	**4**	121.7	48.2
NT06427	134.4	3493.3	47.1	129.7	3124.0	45.4	3261.5	43.7	3296.9	**11**	125.2	44.7
NT07403	129.5	4182.0	47.1	125.7	3660.3	46.6	3426.5	42.3	3797.5	**2**	119.4	44.2
NT09423	137.9	3939.0	48.0	133.0	4007.0	47.2	3559.5	40.8	3869.6	**1**	129.9	44.6
NT10417	135.9	3439.0	51.1	127.3	3627.0	48.1	3452.5	42.4	3512.9	**8**	125.5	46.0
NT11406	137.5	3764.0	49.4	132.7	3527.3	46.0	3432.0	43.8	3592.3	**6**	129.4	45.8
NT11410	135.5	3806.3	48.6	129.0	3488.3	46.5	3200.0	40.3	3535.5	**7**	126.5	44.6
NT11428	137.4	4080.3	54.7	132.7	3629.0	50.0	3039.0	48.8	3650.8	**5**	129.2	51.2
Overland	139.2	3137.7	38.4	131.0	3668.3	44.7	3507.0	34.7	3429.0	**9**	129.7	37.1

It is clear that we have made great 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. (*Sr2, SrAmigo, SrTmp, SrR, Sr6, Sr22, Sr 24, Sr25, Sr26, Sr 36, Sr39*, and *Sr 40*).

Work continues on introgressing the resistance from *Agropyron* (*Wsm1,* the first real resistance/tolerance to wheat streak mosaic virus [WSMV] developed by Dr. Joe Martin, Kansas State University at Hays, KS and his co-workers) into adapted wheat varieties. The newer source for resistance/tolerance, *Wsm2*, developed by Scott Haley (CSU) in collaboration with KSU is also being introgessed. It seems to have less effect on agronomic performance, but also may not be as effective in Nebraska as *Wsm1*. A number of lines that may have this source of resistance were given to Dr. Gary Hein, entomologist, who is testing them in the field. The frequency of lines carrying virus resistance remains far lower than expected. There appears to be a genetic segregation distortion in heterozygous plants with the progeny often not carrying the gene or that the lines are lost during selection for better agronomic types. However, we continue make numerous crosses as this is a key trait for Nebraska. The field assay is by far the best method to determine the tolerance to this virus. With the continued spreading of wheat soilborne mosaic virus into our Lincoln fields (a key early generation testing site), we are now able to select for wheat soilborne mosaic virus resistant lines and many of lines have this beneficial trait.

11. **Understanding the Stem Rust Resistance in 'Gage' Wheat:** T. Kumssa, P.S. Baenziger, S. Wegulo, M. Rouse, and Y. Jin.

Wheat (*Triticum spp.*) stem rust, caused by *Puccinia graminis* f. sp. *tritici* Eriks. & E. Henn. (*Pgt*), re-emerged as a devastating disease of wheat because of virulent race Ug99 (TTKSK). Many bread wheat (*T. aestivum* L.) cultivars grown in North America are susceptible to Ug99 or its derivative races that carry additional virulence. 'Gage' was released in 1963 mainly for its excellent field resistance to leaf rust (caused by *Puccinia triticina* Eriks) and stem rust. However, Gage's resistance has not been genetically characterized, which would facilitate its use in breeding programs. To better define the nature of the resistance in Gage, we created an F_2 population and the corresponding $F_{2:3}$ and $F_{4:5}$ families from crosses between Gage and stem rust susceptible cultivar 'Bill Brown.' Inheritance of resistance to *Pgt* race QFCSC and molecular marker analysis indicated that *Sr2* and additional genes explain the stem rust resistance of Gage. Using seedling plant infection types from the F_2, $F_{2:3}$ and $F_{4:5}$ families, we found that at least one dominant and most likely one recessive gene are involved in Gage's resistance. Seedling resistance genes acted independently of *Sr2* since *it* is effective only at the adult plant stage. To further study this resistance, we created a recombinant inbred-line population, which is being tested at St. Paul, MN, increased at Ithaca, NE. Many lines are being tested next year in Kenya where the global Ug99 testing is being done.

12. Association Mapping for Important Biotic & Abiotic Related Traits in a Structured Wheat Breeding Population: I. Salah, J. Poland, K. Eskridge, A. Lorenz, and P.S. Baenziger

This research focuses on applying genomic selection methods in our breeding program using different statistical approaches to build new applicable protocols that will be used to improve our selection. We are specifically interested in effectively building the genotype by environment interaction (GxE) into our models because we occasionally have years like 2012 (the earliest in the last 29 years) which are very unrepresentative for phenotypic selection and our main early generation selection nurseries are in eastern Nebraska while most of our wheat is grown in western Nebraska. We also hope to build over-year models to ranks lines that are developed in different years to see how they are predicted to perform in the future. However, we are constantly adding new germplasm into our breeding program and it is presumed that with this new germplasm we can also bringing in new alleles not seen in previous years. As such we will need to blend current year genotyping and phenotyping with our over-year genotyping and phenotyping so as not to bias our selection only toward those alleles that we have previously used in our breeding program. In 2015 we have expanded our genotyping from the duplicate (preliminary yield trial, ~ 273 lines) to the preliminary observation nursery (~2000 lines).

13. Fusarium Headblight (FHB) Research: S. Wegulo, G. Bai, P. S. Baenziger

In previous research, we found *Fhb1*, a major gene for scab (syn. Fusaium head blight) tolerance, was not pleiotropic or linked to genes that reduce grain yield. We are using high yielding *Fhb1* lines from segregating populations and Wesley *Fhb1* study in our crossing block. For the first time, we are seeing lines in our multiple-location observation nursery that contain *Fhb1*, indicating our breeding strategy is beginning to work. In addition, Dr. Guihua Bai has created a number of Overland backcross *Fhb1* lines, which are also extensively being used in the greenhouse-crossing block. Overland has a native tolerance which with the added tolerance conveyed by Fhb1 could be extremely valuable in creating new cultivars with tolerance to scab. Of course, Overland has been a very popular and high yielding cultivar in Nebraska, which makes its use as a parent very attractive. Finally, Guihua has made a number of NE06607 *Fhb1* lines, which may have value in our organic breeding research, as NE06607 has the right combination of disease resistance, agronomic performance, and end-use quality attributes.

14. Breeding for Organic Systems: R. Little, P. S. Baenziger, T. Regassa

In 2013 and 2014, the Organic State Winter Wheat Variety yield trials (SVT) at Clay Center were planted after alfalfa rather than after soybeans as in previous years. Planting after alfalfa enabled timely planting on September 24 in 2014 and October 3 in 2013 compared to as late as October 31 in previous years and contributed to yields several bushels higher than in conventional trials in 2014. The small overlap in number of lines being tested in conventional and organic environments is a testament to differential criteria and performance. See the following table and http://cropwatch.unl.edu/web/varietytest/wheat. The high LSD indicates that the top 17 lines were not significantly different than the top-yielding line. Three new experimental lines, NE10507, NE11499, and NE12589 yielded in the top five.

The second and final year was completed for testing 12 cultivars and experimental lines in environments after either soybeans or alfalfa in a "Nitrogen-Use-Efficiency-for-Quality" experiment. Baking of white bread and reconstituted whole wheat bread is in process for each of these lines at 2- or 3-protein content levels. The samples are composites of wheat from both alfalfa and soybean environments. Samples from the soybean environment were cleaned on a Carter Density Separator to remove bunt spore balls. Cold soils from this environment, planted five weeks after the alfalfa environment, were conducive to spore germination. Soil samples were collected from each plot in early spring and in July of 2014. Soil nitrogen, nitrate, and ammonium changes will be compared to the amount of nitrogen in the harvested grain to determine whether low-protein lines that bake well use as much nitrogen as the high-protein lines. Karl 92 and Lyman are the benchmark high protein lines on different ends of the yield spectrum.

Cultivar	SVT14 CC Organic	SVT14 CC Conventional	SVTCC Organic
	Grain Yield (bu/acre)	Grain Yield (bu/acre)	Grain Protein Content (%)
Expedition	72		14.2
NE10507	72		13.0
NW03666 (W)	71		13.7
NE11499	71		14.9
NE12589	70		13.6
NE09521	70		13.6
Lyman	68		14.7
Goodstreak	68		14.4
Camelot	68	58	14.0
Overland	67	63	13.9
NW03681 (W)	67		14.3
SD07165	67		13.1
NE06469	67		13.7
Freeman	66	57	13.6
NW07505 (W)	66	60	13.4
NE07409	65		13.1
NE06607	65		14.0
McGill	64	54	13.3
NE08659	63		13.3
NE12662	63		13.8
Arapahoe	62		14.0
NE07444	62		14.2
NIO8708	62		13.9
Wahoo	60		13.2
Karl 92	57		15.3
NE12524	56		14.8
Pronghorn	56		14.2
NE08457	54		14.4
NE02558	54		13.7
Turkey	52	43	14.5
NW09627	50		13.6
Scout 66	47	38	14.3
Mean	63	54	13.9
LSD.05	7	6	0.3

15. Variation for Grain Mineral Concentration in a Diversity Panel of Current and Historical Great Plains Hard Winter Wheat Germplasm: M. Guttieri, P.S. Baenziger, K. Frels, B. Carver, B. Arnall, and B. Waters**.**

Wheat grain mineral concentrations tend to decrease as yields increase, therefore breeding for yield improvement may have reduced wheat nutritional quality. The study objective was to survey grain mineral concentration in Great Plains hard winter wheat to assess:

1) the heritable variation for grain mineral concentrations in the germplasm pool;
2) the effects of more than 50 years of wheat breeding on mineral concentrations; and
3) opportunities to exploit the underlying physiological relationship between grain protein concentration (GPC) and grain mineral concentration to improve nutritional quality.

Grain mineral concentrations were measured in a panel of 299 winter wheat genotypes grown in 2012 and 2013 in Oklahoma and Nebraska. Cadmium and Li concentrations were most heritable across environments, and the low heritabilities of Fe and Zn concentrations will challenge direct breeding efforts, particularly within low-yield environments that minimize genetic variance. Within the subset of cultivars released from 1960 to 2014, grain yield increased 0.58 to 1.25 % yr^{-1}, and Zn concentration decreased 0.15 to 0.26% per year, relative to the reference cultivar, 'Scout 66.' Grain concentrations of Fe, P, and S also trended lower over this time. Significant genetic variation persists within contemporary germplasm: among 93 cultivars released since 2000, Zn concentration max:min ratios ranged from 1.5 – 2.3, depending on environment. The positive interrelationship between GPC and grain Fe and Zn concentrations could be exploited in a yield-neutral breeding strategy that selects genotypes based on positive grain protein deviation in multiple environments.

16. Prospects for Selecting Wheat with Increased Zinc and Decreased Cadmium Concentration in Grain: M. Guttieri, P.S. Baenziger, K. Frels, B. Carver, B. Arnall, S. Wang, E. Akhunov, and B. Waters

Wheat (Triticum aestivum L.) is a primary staple cereal and a significant source of mineral nutrients in human diets. Therefore, increasing concentration of the essential mineral, zinc (Zn), and decreasing concentration of the toxic mineral, cadmium (Cd), could significantly improve human health. Because plant mechanisms for uptake and translocation of Cd and Zn are related, we assessed both Cd and Zn concentration to evaluate their independence in hard winter wheat germplasm. 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. However, grain Zn concentration was not predicted by Zn concentration in above-ground plant tissues. 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.). Genetic regulation of grain Cd concentration in bread wheat may be more complex than in durum wheat because epistatic interactions between SNP markers were identified, and not all variation was explained by SNP marker haplotypes. SNP marker associations with Zn concentration were weak and inconsistent across trials, and Zn concentration was independent of 5AL SNP markers. The independent genetic regulation of grain Cd and Zn concentrations indicates that breeding low Cd hard winter wheat genotypes without reducing Zn concentration has high potential for success.

17. Choosing the Best Vegetation Index for Use in Nitrogen Use Efficiency Selection in Winter Wheat: K. Frels, M. Guttieri, P.S. Baenziger

Nitrogen use efficient (NUE) crops are needed to reduce increasing nitrogen costs and environmental concerns. However selecting for NUE wheat is difficult due to the labor intensive and destructive nature of traditional phenotyping methods. Canopy spectral reflectance (CSR) is non-destructive, quick, and less labor intensive phenotyping method that measures incident light reflected by the plant canopy. Reflectance values for specific wavelengths are selected and used to calculate vegetation indices such as Enhanced Vegetation Index (EVI). These vegetation indices can be used to estimate specific traits related to nitrogen use efficiency such as biomass, canopy N content at flowering, and yield. During the 2012 and 2013 growing seasons, a 299-genotype hard winter wheat-association mapping panel grown near Ithaca, NE was phenotyped weekly from anthesis to physiological maturity using CSR. Biomass samples were harvested at anthesis and physiological maturity. Protein concentration in vegetative tissues and grain was measured using a Perten DA7200 diode array NIR (Hägersten, Sweden). Grain N yield was calculated as (grain yield x grain protein content x 0.01)/5.7. Several vegetation indices were calculated from this data set. The plant productivity traits such as anthesis biomass, grain yield, and grain N yield were compared with the vegetation indices. In 2012, a year with a yield-limiting environment, EVI (Enhanced Vegetation Index) was highly heritable and showed high correlation with all plant productivity traits. In 2013, an optimal yield year, all VI had high heritability but were less sensitive to genotype differences. Alternative VI or analysis methods will be needed for optimal years.

18. Breeding for Nitrogen Use Efficiency in Hard Winter Wheat Using Canopy Spectral Reflectance and Genomic Selection: K. Frels, M. Guttieri, P.S. Baenziger

Nitrogen use efficient (NUE) crops are needed to reduce increasing nitrogen costs and environmental concerns. However, traditional phenotyping methods for NUE are labor intensive and destructive. Canopy spectral reflectance (CSR) is non-destructive, quick, and less labor-intensive phenotyping method that measures incident light reflected by the plant canopy. Reflectance values for specific wavelengths are selected and used to calculate vegetation indices that estimate traits such as chlorophyll content and biomass. During the 2012 and 2013 growing season, the USDA-NIFA Triticeae Coordinated Agricultural Project (TCAP) supported proximally-based CSR phenotyping in the 299-genotype hard winter wheat association mapping panel grown near Ithaca, NE. CSR data was collected weekly from anthesis to physiological maturity using a dual-fiber optic system allows for adjustment to incident light. Entry mean heritability of vegetation indices was calculated, and the most heritable indices were used in a G-BLUP genomic selection model using SNP markers. Prediction accuracy was estimated using 10 fold cross validation replicated 100 times. In 2012, accuracy for EVI phenotypes ranged from 0.38 for week 1 EVI to 0.57 for week five EVI showing that genomic selection combined with CSR data was successful in predicting unphenotyped lines within same year. Analysis for 2013 and testing the prediction accuracy of genomic selection and CSR data across years/environments is ongoing.

19. Hybrid Wheat: N. Garst, A. Easterly, P.S. Baenziger, A. Ibrahim

The interest in hybrid wheat has been in the literature for the better part of the 20^{th} century, and work has been undertaken by various seed companies. A number of challenges have limited its success. The constraints of budgeting, logistics and biological limitations of hybridization in an autogamous species, and the time investment in feasibility projects ultimately led to the end of programs. It has been argued that hybrid wheat may not be a feasible undertaking as the crop lacks the mechanical advantages to seed production and predisposition to cross-pollination, a phenomenon that has made hybrid maize a profitable endeavor. Research has begun to evaluate Nebraska breeding lines for better male parent characteristics to improve the amount of pollen available for cross-pollination. In wheat, recent estimates of yield increase of hybrids over elite parents has been estimated to be at 10.7%. Likewise, increased resistance to pathogens and pests has been noted. As such, the goal of this research is to evaluate the extent to which yields of wheat could be increased in hybrids, to develop commercially successful varieties for farmers in the Great Plains.

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 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. Commercial production of these chemicals has been in place for a number of years. 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 hybrid seed.

In order for hybrid wheat to be commercially successful, a number of characteristics must be considered. First, we must find effective hybridization system on a large scale. For this, the small grains program at UNL will be developing and examining potential hybrids developed through use of CHAs, then evaluating the potential for a CMS system to produce commercial hybrids. Crossing blocks were planted in the fall of 2014 for treatment with CHA in 2015 to develop a set of experimental hybrids. Hybrid seed comes at an annual cost to farmers, who are able to obtain seed at low cost from local co-ops or public breeding programs. The performance of a hybrid must well exceed that of any current commercial cultivars in either yield, vigor, disease- and pest-resistance, the ability to seed at a reduced rate, or any combination thereof to be worth the added cost. With this in mind, evaluation must be made to precisely determine the amount of heterosis exhibited for yield and other key traits in hybrid wheat such that the increase in productivity justifies the cost for both producers and researchers. This will be examined in our experimental population of hybrids in the 2015/2016 and 2016/2017 growing seasons. Greenhouse work to identify R-lines is underway in conjunction with the introgression of male sterile cytoplasm into Nebraska-adapted winter wheat lines. Most current wheat breeding is done for the development of inbred cultivars, and as such, no true heterotic pools have been identified. Through utilization of modern genomic systems, we will work to build reliable and high-performing heterotic pools for hard winter wheat.

Another major pitfall for the success of hybrid wheat has been the cost of producing hybrid seed. Due to the cleistogamous nature of wheat, the amount of pollen available to pollinate male sterile (female parents) is low. The lack of pollen requires hybrid production fields to be planted with more male parents to get proper cross-pollination. Production costs increase because the product (F1 seed) is planted on less area. Research is being conducted on improving certain characteristics, which would increase the amount of available pollen. The first of these characteristics is anther extrusion, which is the ability of the wheat anthers to break out of the spikelets. Initial ratings for anther extrusion were done during the 2013/2014 growing season with some success. Research in the 2014/2015 growing season will focus on better calibrating the metric and rating the parents in the crossing block. Lines which have the highest ratings for anther extrusion will then be evaluated for amount of pollen shed, pollen flow (distance traveled), and pollen viability during the 2015/2016 growing season. The goal is to validate the selections and look for correlations between floral traits.

20. Enhancing wheat (*Triticum aestivum* L.) drought tolerance using SNP markers based on high throughput genotyping by sequencing technology: W. Hussain, P.S. Baenziger, M.Guttieri)

Drought globally is the most wide spread 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. This present study will grow lines across a diverse range of environments (Lincoln, Mead, Grant, Sidney, Alliance and North Platte) where different levels of drought naturally occur with following objectives:

1) Screening recombinant inbred lines (RILs) and their parents (Harry and Wesely) for grain yield components and several morpho-physiological traits in response to drought;
2) Developing high-density SNP markers for better marker trait association using genotyping by sequencing approach;
3) Assessing the stability of the various morpho-physiological traits and investigating the occurrence of genotype x environment interaction; and
4) Identification of QTLs and QTL x environment effects for several morpho-physiological traits. The ongoing research will facilitate fine mapping of selected trait genes in response to drought, providing a foundation enabling the development of superior wheat varieties.

21. Combining ability for tolerance to pre-harvest sprouting in wheat: J. Fakthongphan, R. Graybosch and P.S. Baenziger

Pre-harvest sprouting (PHS) can have a significant impact on wheat (*Triticum aestivum* L.) production, yield, and end-use product quality, leading to massive economic losses. Red wheats are normally more resistant to PHS than white wheats. The objective of this study was to identify red wheats capable of donating genes for PHS tolerance in white wheats, independent of red seed color. A factorial (M × N) mating was conducted using eight red wheats: 'Niobrara,' 'Wesley,' 'Arapahoe,' NE98466, CO960293-2, 'Jagalene' NI01812 and 'Plainsman V' and six white wheats: 'Nuplains,' NW99L7068, 'RioBlanco,' 'Cayuga,' NW97S218, and 'Peck.' General combining ability (GCA) for individual parents and specific combining ability (SCA) for specific crosses were used to identify effective donor red wheat parents. GCA and SCA were calculated from a pre-harvest tolerance score (Delta Value) determined after testing head selections in a misting chamber, and from Falling Number measurements of field-grown materials. GCA amongst red parents (GCAr) was significant for both Delta Value and Falling Number, but not in white parents (GCAw). GCA or SCA by environmental interactions, with the exception of the Delta Value from GCAr, were significant. Jagalene and Niobrara were identified as potential red wheat genetic reservoirs for additional genes of PHS tolerance. A significant correlation of SCA of Falling Number and SCA of Delta Value was detected (r = 0. 38, n = 48, P = 0.007). Falling Number assay can be replaced by Delta Value assay for evaluating PHS tolerance in wheat breeding programs in areas in which pre-harvest sprouting is not routinely observed.

IV. GREENHOUSE RESEARCH

In 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.

V. PROPRIETARY RESEARCH

Public Private (University of Nebraska) Collaborations:

In 2009, the University of Nebraska decided to sustain the whea-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 are now concentrating on two-gene herbicide tolerant wheat cultivars. In 2009, UNL began collaboration with ConAgra (now part of Ardent Mills).

They support our McCook Nursery and provide valuable information on the end-use quality of our lines at that site, which 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. 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.

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

We received our 11th 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) had a good year.

We had extensive winterkilling on barley in eastern Nebraska. At Lincoln, it was mainly due to blowing (the plants were destroyed by wind and blowing soil). At Mead, the winterkilling was mainly due to low temperatures. Of the two locations, the data from Mead is more valuable as winter survival under low temperatures is the more common occurrence. We were able to harvest yield trials at Colby, KS (good yields despite drought) and Sidney, NE (lower yields due to poorer stand establishment caused by heavy rains after planting). We were able to harvest sufficient seed from Lincoln to advance our breeding program. 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.

Though the winterkilling was severe in eastern Nebraska where our main breeding nurseries are, we were able to salvage the breeding program. In fall, 2014, we planted a new set of F2s and the surviving F3 populations. Our headrow nursery was reduced by about 30%, but we expect the lines to be very winterhardy. The remaining nurseries have their normal size.

Figure 1. Winter survival of winter barley at Mead Nebraska. As seen above, the winterkilling was most severe in the winter barley block followed by the winter triticale block. Except in segregating bulk populations with spring wheat parents, there was no winterkill among the wheat lines. Where virtually all of the winter barley was killed (a Barley CAP trial and the winter malting barley trial), the surviving plots were winter wheat check plots. The barley that survived the winter was the Nebraska intermediate and elite trial and the F_3 populations, which previously survived the winter of 2013 as F_2 populations

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.

The 2014 barley data are:

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**	

Of the released cultivars (Table 1), P-954 did very well as expected, because it is one of the most winter-hardy lines developed at UNL. P-845 (released last year) also did very well. One of the surprises was that TAM BAR 501 (developed in Texas and which normally has acceptable winter-hardiness) did poorer than normal in Colby, KS and Sidney, NE.

The 2013 barley data are:

	Colby			Lincoln				Mead					
	Plant Height	Grain Yield	Test Weight	Heading Date	Plant Height	Lodging (rate)	Grain Yield	Heading Date	Plant Height	Lodging (rate)	Grain Yield	Mean Yield	
Name	**Inch**	**lbs/a**	**lbs/bu**	**After April 1**	**Inch**	**0-9**	**lbs/a**	**After April 1**	**Inch**	**0-9**	**lbs/a**	**lbs/a**	**Rank**
NB12437	22	1505	45	19	33	0	5212	22	31	2	5664	**4127**	**1**
NB11430	23	1700	45	18	34	0	5369	20	31	1	5242	**4104**	**2**
NB10425	21	1946	47	19	33	0	5329	24	33	1	4993	**4089**	**3**
P-845 (NB99845)	18	1670	45	19	31	0	5247	23	30	0	5240	**4052**	**4**
NB09404	21	1720	46	18	35	0	5084	20	33	0	5242	**4015**	**5**
NB12424	18	1576	45	19	31	0	5144	23	32	0	5278	**3999**	**6**
NB12419	20	1890	48	20	31	0	4784	23	32	0	5237	**3970**	**7**
NB12434	20	1551	47	17	31	0	5155	21	30	2	5082	**3929**	**8**
NB09409	19	1782	47	19	32	0	5057	23	33	2	4942	**3927**	**9**
NB09410	21	1665	50	19	36	0	4968	22	33	0	5047	**3893**	**10**
NB10444	20	1724	49	18	29	0	4946	21	30	2	4973	**3881**	**11**
NB12431	18	1266	45	18	30	0	5485	22	30	1	4795	**3849**	**12**
NB12426	20	1609	43	19	34	0	4822	24	33	2	5062	**3831**	**13**
TAMBAR 501	19	1518	39	18	31	0	5328	20	31	1	4646	**3831**	**14**
NB12421	19	1661	45	20	30	0	4938	24	30	2	4892	**3830**	**15**
NB10417	19	1621	44	18	32	0	5429	19	30	2	4304	**3785**	**16**
NB09437	21	1463	47	19	36	0	5246	22	31	1	4550	**3753**	**17**
NB11416	20	1585	42	19	33	0	4990	22	30	4	4670	**3748**	**18**
NB10403	23	1251	43	15	34	0	5216	18	33	1	4774	**3747**	**19**
NB12425	20	1746	47	20	31	0	4709	23	33	3	4762	**3739**	**20**
NB11414	19	1859	42	18	32	0	4804	25	32	0	4456	**3706**	**21**
NB09425	18	1453	44	19	29	0	4789	23	28	1	4838	**3693**	**22**
NB10420	21	1434	36	15	35	0	5027	19	33	0	4584	**3682**	**23**
P-713	20	1638	49	19	34	0	4567	22	35	3	4724	**3643**	**24**
P-954	17	1472	38	19	31	0	4602	23	31	4	4831	**3635**	**25**
NB12422	19	1732	46	19	31	0	4307	22	31	2	4794	**3611**	**26**
NB12436	21	1713	44	20	34	2	4451	22	33	2	4622	**3595**	**27**
NB10440	21	1577	52	17	32	0	4772	21	33	1	4388	**3579**	**28**
NB12433	19	1137	33	18	31	0	4609	21	33	0	4907	**3551**	**29**
NB12408	17	1412	37	19	31	0	5041	22	26	0	4129	**3527**	**30**
NB09441	20	1063	31	18	34	0	5083	21	30	0	4420	**3522**	**31**
NB08428	22	1516	37	19	31	0	4687	23	30	2	4335	**3513**	**32**
NB11418	17	1481	37	19	30	0	4904	22	29	1	4128	**3504**	**33**
NB12440	19	1295	38	19	34	0	4544	27	32	0	4637	**3492**	**34**
NB11438	21	1360	42	18	32	0	4215	21	32	0	4857	**3477**	**35**
NB12417	17	1826	47	23	28	0	3899	27	28	2	4687	**3471**	**36**
NB12418	19	1165	45	17	31	0	4932	19	32	1	4169	**3422**	**37**
NB10409	19	1546	35	18	35	1	4124	20	32	1	4581	**3417**	**38**
P-721	19	1487	53	19	31	2	3494	22	29	3	4492	**3158**	**39**
NB12403	24	687	32	18	32	0	4240	22	33	0	4055	**2994**	**40**
Mean	**20**	**1532**	**43**	**19**	**32**	**0**	**4839**	**22**	**31**	**1**	**4751**	**3707**	
CV %	**7**	**17**	**22**	**1**	**4**	**252**	**7**	**1**	**5**	**126**	**9**		
LSD 5%	**2**	**368**	**13**	**1**	**2**	**1**	**516**	**2**	**3**	**3**	**673**		

The 2012 barley data are:

Winter Barley Variety Trial (BVT) 2012 Summary for Lincoln and Mead, NE

VARIETY	Lincoln				MEAD				Across Locations	
	Anthesis	PHT	YLD	Rank*	Anthesis	PHT	YLD	Rank	YLD	Rank
	(after April1)	*Inch*	*lbs/a*		*(after April1)*	*Inch*	*lbs/a*		*Lbs/a*	
P-713	19	35	4784	**15**	24	35	5563	**3**	5173	**7**
P-721	21	31	3908	**36**	26	32	4786	**25**	4347	**33**
P-954	23	32	3218	**39**	25	32	4564	**33**	3891	**39**
TAMBAR 501	16	34	4772	**17**	21	35	5375	**9**	5073	**11**
NB08428	20	33	4332	**27**	23	34	5385	**8**	4859	**18**
NB09404	20	34	4732	**18**	24	36	5493	**5**	5113	**9**
NB09405	16	32	3668	**38**	22	35	4570	**32**	4119	**36**
NB09409	20	32	4608	**21**	25	35	5254	**11**	4931	**15**
NB09410	19	35	5216	**5**	23	37	5842	**2**	5529	**2**
NB09425	19	30	4811	**14**	25	32	5200	**13**	5006	**13**
NB09427	24	32	4185	**30**	27	35	5253	**12**	4719	**24**
NB09430	14	33	4064	**32**	21	37	4888	**21**	4476	**28**
NB09432	22	33	4083	**31**	26	35	4236	**39**	4160	**35**
NB09433	21	32	4242	**29**	26	34	4627	**28**	4434	**31**
NB09434	20	33	4295	**28**	25	32	4833	**24**	4564	**25**
NB09437	20	36	5321	**3**	24	36	6064	**1**	5692	**1**
NB09439	20	32	4636	**19**	24	33	4886	**23**	4761	**21**
NB09440	13	33	3935	**34**	21	35	4285	**37**	4110	**37**
NB09441	18	34	4903	**12**	21	36	5017	**17**	4960	**14**
NB10403	13	34	4951	**9**	21	38	4740	**27**	4846	**19**
NB10404	14	34	4556	**22**	21	35	4241	**38**	4399	**32**
NB10409	15	37	5023	**8**	22	38	4760	**26**	4892	**16**
NB10417	15	31	5077	**6**	21	35	5177	**14**	5127	**8**
NB10420	14	33	4774	**16**	21	36	5000	**18**	4887	**17**
NB10421	18	34	4934	**11**	24	35	4508	**34**	4721	**23**
NB10425	20	37	4951	**9**	25	35	5075	**15**	5013	**12**
NB10440	15	33	4891	**13**	22	35	5265	**10**	5078	**10**
NB10444	16	31	5536	**1**	21	35	5435	**6**	5486	**3**
NB11404	16	34	2848	**40**	21	35	3200	**40**	3024	**40**
NB11405	19	35	4516	**23**	25	37	4589	**29**	4552	**26**
NB11414	19	32	5488	**2**	23	35	4887	**22**	5188	**6**
NB11416	20	34	5035	**7**	24	35	5543	**4**	5289	**5**
NB11418	16	32	4611	**20**	22	33	4952	**20**	4782	**20**
NB11419	19	32	4335	**26**	22	34	4583	**30**	4459	**29**
NB11427	18	31	4033	**33**	22	33	4983	**19**	4508	**27**
NB11429	21	34	3782	**37**	23	33	4425	**36**	4104	**38**
NB11430	17	35	5219	**4**	21	36	5423	**7**	5321	**4**
NB11431	20	31	3911	**35**	25	31	4582	**31**	4247	**34**

NB11432	19	33	4398	25	24	34	4489	35	4443	30
NB11438	17	33	4459	24	22	35	5050	16	4755	22
Mean	**18.18**	**33.22**	**4526.1**		**23.10**	**34.68**	**4925.7**			
Coeff Var	**1.05**	**1.38**	**7.57**		**4.52**	**3.02**	**8.44**			
Root MSE	**1.47**	**1.38**	**342.45**		**1.05**	**1.05**	**415.61**			
R-Square	**0.91**	**0.68**	**0.81**		**0.81**	**0.78**	**0.70**			
LSD (p=0.05)	**1.71**	**2.37**	**556.66**		**1.69**	**1.70**	**675.58**			
P-value	**<0.0001**	**<0.0001**	**<0.0001**		**<0.0001**	**<0.0001**	**<0.0001**			

VI. 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, 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.

VII. 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. Dr. Mary Guttieri completed her Ph.D. degree and continues to help the project immensely while working on a postdoc with Dr. Brian Waters. Ms. Caixia Liu, Ms. Amanda Easterly and Mr. Javed Sidiqi joined the program as Ph.D. students. Dr. Hanaa Abouzeid joined the project as a Fulbright visiting scholar. We are extremely grateful for the excellent work that the team has done and continues to do.

Summary:

In 2013-2014 season, 1,550,000 acres of wheat were planted in Nebraska and 1,450,000 were harvested with an average yield of 49 bu/a for a total production of 71,050,000 bu. This production was almost 180% higher than the 2012-2013 crop, which bodes well for wheat producers. In 2012-2013 season, 1,470,000 acres of wheat were planted in Nebraska and 1,130,000 were harvested with an average yield of 35 bu/a, for a total production of 39,550,000 bu. The 2012-2013 crop was one of the smallest crops in the last 50 years and certainly highlighted the effect of drought. In 2012, 1,380,000 acres of wheat were planted in Nebraska and 1,300,000 were harvested with an average yield of 41 bu/a, for a total production of 53,300,000 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.

Using seed sales of certified seed, the top 10 lines grown in Nebraska in 2014 were: Settler CL (15.4%), Overland (12.4%), Tam 111 (9.4%), AP502CL2 (6.3%), Winterhawk (5.6%), Wesley (5.1%), Pronghorn (5.0%), Infinity CL (4.3%), Art (3.6%), and Camelot (3.3%). In 2014, NE05548 winter wheat was formally released and will be marketed as Husker Genetics Brand Panhandle, as was NT065427 winter triticale licensed to Ehmke Seeds. The decision to release Panhandle was made in 2013 and its description may be found in the 2013 report. The description of NT06427 is in this report. NT06427 was licensed to Ehmke Seeds and is expected to be marketed under the name Short Beard Thunder. A third line (NW07505) is being tested by and considered for release to our organic producers. The importance of certified seed is recognized by our growers and the best estimate by the Nebraska Crop Improvement Association is that 78% of our planted seed is certified seed. Clearly the popularity of Clearfield® cultivars, which require planting only certified seed, help the use of certified seed. Four lines (NE07531, NE09517, NE09521, and NE10589) were advanced for possible release in 2015 or 2016. Of these, NE10589 is the most widely adapted and has the greatest potential.

Recent studies on nitrogen use efficiency (NUE) and on minerals identified Husker Genetics Brand Freeman as being particularly good for NUE, among the best lines available. As part of the NUE studies, we looked at mineral content in wheat grain. The original intent of doing mineral analyses was that we were concerned we may be misclassifying winter wheat varieties as having low NUE when in fact they were mineral deficient. We discovered that there is genetic variation for cadmium (Cd, a harmful heavy metal) in Great Plains hard red winter wheat. Interestingly, the recently released Panhandle winter wheat is a low Cd accumulation wheat. As it is a common parent in our breeding program, we will develop additional low Cd varieties in the future. Breeding environmentally sustainable small grains with better health benefits will be a major thrust of our program and for the betterment of the Wheat Industry as a whole. It will also position us well in the emerging flex crop/cover crop market where blends of crops are used to meet environmental and farm goals.

Our hybrid wheat efforts have greatly increased with the hiring of two graduate students to work on this project. 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. Even if hybrid wheat may be years away, the knowledge on heterosis (hybrid vigor) will be extremely valuable to our conventional breeding program as it will allow us for the first time to truly look at the performance and genetics of hybrid crosses. Nor should we overlook the potential of adding numerous elite by elite populations to our conventional breeding efforts.

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 working with organic producers. We have released a new forage triticale and have numerous potential releases in the pipeline. Our barley breeding effort remains strong. Both triticale and barley are excellent alternative crops to wheat if there is a catastrophic event in wheat. For example, barley is immune to karnal bunt should it return to the Great Plains. **Our program gratefully acknowledges the generous support of the Nebraska Wheat Board.**