IMPROVING SMALL GRAINS VARIETIES FOR NEBRASKA

2020 STATE BREEDING AND QUALITY EVALUATION REPORT

Report to the

NEBRASKA WHEAT DEVELOPMENT, UTILIZATION
AND MARKETING BOARD

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I. INTRODUCTION

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

II. THE 2019-2020 NEBRASKA WHEAT CROP

1. <u>Growing Conditions</u> and Crop Production

Planted acres: 900,000; Harvested acres: 830,000 acres (a new record low): Yield/acre: 41.0 bu a^{-1}; Total Crop Size: 34,030,000 bu. The crop acreage was lower than previous years as part of a continuing trend. However, it was also lower due to a wet fall in 2019 which prevented the summer annual crops from being harvested on time so that that winter wheat could be planted. The lower yield was in part due to delayed planting in the center to east and drought in the west. In the west, drought, high temperatures, and wind reduced grain yield. In the east, diseases were moderate and in the west, the major concern was the insect pest wheat stem sawfly. There was little winterkill in wheat or triticale, but winter barley was injured if planted late. All in all, this would be considered an average wheat crop.

In 2018-2019 season, 1,070,000 acres of wheat were planted in Nebraska (the previous record low) and 970,000 acres were harvested with an average yield of 57 bu/a (a record high) for a total production of 55,300,000 bu. In 2017-2018 season, 1,100,000 acres of wheat were planted in Nebraska and 1,010,000 were harvested with an average yield of 49 bu/a for a total production of 49,490,000 bu. The crop generally got off got a good start and survived the winter, but in the spring periodic episodes of drought and extreme heat (100 F at flowering) affected part of the crops. Leaf rust was the main disease and wheat stem sawfly was the major insect pest. In 2016-2017 season, 1,120,000 acres of wheat were planted in Nebraska and 1,020,000 were harvested with an average yield of 46 bu/a for a total production of 46,920,000 bu. The crop generally got off got a good start and survived the winter, but in the spring a number of diseases and wheat stem sawfly were abundant. In western and central Nebraska, wheat streak mosaic virus was quite common. Wheat stem sawfly also continued to expand into Nebraska from the west, though fortunately parasitoid wasp populations have increased and lessened some of the damage, particularly in the northern Panhandle. In eastern Nebraska, the rusts (led by stripe rust and then leaf rust were very common). In 2015-2016 season, 1,370,000 acres of wheat were planted in Nebraska and 1,310,000 were harvested with an average yield of 54 bu/a (a record yield/acre) for a total production of 70,740,000 bu. In 2014-2015 season, 1,490,000 acres of wheat were planted in Nebraska and 1,210,000 were harvested with an average yield of 38 bu/a for a total production of 45,980,000 bu. Despite continued genetic improvement, the main determinant in wheat production seems to be acres harvested, government programs, and weather (which also affects disease pressure and sprouting). This is an economic reality in understanding wheat yields and productivity in NE. Barley or triticale acreages are not reported in the NASS surveys but the general feeling is that locally produced barley is finding a fit for micromalsters and microbrewers, forage for dairies, and feed for animals. Triticale acreage continues to increase, primarily as an annual forage crop and to a lesser extent as a feed crop.

As for lead cultivars, Nebraska no longer has a cultivar survey, but probably no cultivar has more than 10% of the acreage. 'SY Monument' and 'Wolf' continue to well, as do number of Westbred lines. 'Ruth', 'Robidoux', and 'Freeman' continue to do well also. Two new wheat lines were recommended for release. NW13493 is a new white that is in the processed of being licensed to ensure it has a market. NE15420 is an excellent irrigated hard red winter wheat that is expected to replace Wesley. In addition, a new winter barley and triticale will soon be proposed for release.

2. Diseases

In 2020, in eastern Nebraska, diseases tended to be low though leaf rust and Fusarium head blight NE were present. Fungal disease losses as determined by fungicide trials were 6% or roughly 4 bu a^{-1} (treated yielded 60.3 bu/a and untreated yielded 56.7 bu/a at Lincoln in replicated yield trials). Stripe rust was minor. This level of disease loss is low compared to previous years. The fungicide treated plots were sprayed twice to control potential disease. Wheat streak mosaic virus was generally minor in western Nebraska. The yield losses due to controllable fungal diseases in eastern Nebraska in 2015, 2016, 2017, 2018, and 2019 were 44%, 32%,16%, 7%, and 18%, respectively. Drs. Stephen Wegulo (plant pathologist), Jeff Bradshaw and Gary Hein (entomologists monitoring insect vectors of disease), and Satyanarayana Tatineni (USDA-ARS virologist) continue to be invaluable in disease identification, survey, and understanding. Diseases found on winter barley and winter triticale were mainly ergot and some bacterial streak. Later planting and winter injury was common on winter barley at Mead which delayed winter barley growth and led to a high incidence of stem rust.

3. Insects

Nebraska continues to have small outbreaks of Hessian fly and the diseases vectored by aphids (barley yellow dwarf virus). In 2020, wheat streak mosaic virus (WSMV) and others viruses vectored by mites or aphids were generally minor. Wheat stem sawfly was the main threat in western NE and continued to be pervasive throughout the Nebraska Panhandle and led to crop losses wherever there was severe weather before harvest due to extensive lodging and stem breakage.

4. Cultivar Distribution:

Nebraska began retaking the variety surveys in 2015, however due to financial constraints did not do one in 2017 or thereafter. It is too early to know the certified seed sales for 2020, but there are 48 different cultivars (44 are hard red winter wheat and 4 are hard white winter wheat) available in 2020. It is expected that no cultivar will have more than 10% of the total acreage. Using aggregate data from the Nebraska Crop Improvement Association, approximately 43% of the wheat planted acres were planted to certified seed of 46 different cultivars in 2019. Approximately 67% of the wheat planted acres were planted to certified seed of 46 different cultivars in 2018. The reduction in certified seed usage may reflect the low value of wheat and growers trying to reduce input costs. The certified seed planted acreage will vary by cropping system and region with more saved seed in regions where less seed of other crops are purchased.

III. New Cultivars

The project is in the process of formally releasing NW13493 (SD98W175-1/ NW03666) and NE15420. The pedigree of SD98W175-1 is 'KS84273BB-10'/'KSSB110-9'//'KS831374-141B'/'YE1110'/3/'KS82W418'/'SPN' and the pedigree of NW03666 is 'N94S097KS'/'NE93459'. The cross was made in 2007. The F_1 generation was grown in the greenhouse in 2008 and the F_2 to F_3 generations were advanced using the bulk breeding method in the field at Mead, NE in 2009 to 2010. In 2011, single F_3-derived F_4 rows were planted for selection at Lincoln, NE. The $F_{3:5}$ was evaluated as a single four row plot at Lincoln, NE and a single row at Mead, NE in 2012. NW13493 was identified in 2013 as the experimental line, NW13493, and selected for further testing. The only selection thereafter was to remove contaminant red kernels. This line seems to be broadly adapted throughout Nebraska for rainfed production systems. It was selected using both phenotypic including for its white kernels and genomic selection.

NW13493 was evaluated in Nebraska replicated yield nurseries starting in 2013, in the USDA-ARS coordinated Southern Regional Performance Nursery in 2016 and 2017 and in the University of Nebraska Fall Sown Wheat Performance Trials in 2017 to 2020. NW13493 performed extremely well across Nebraska in head-to-head comparisons for grain yield with the currently popularly available wheat cultivars. It was significantly or non-significantly higher yielding than all of the comparative cultivars. These data are supported by the 2016 and 2017 USDA-ARS Southern Regional Performance Nursery where NW13493 ranked 16th and 11th region-wide of the 38 and 50 entries tested in those years (data available at http://www.ars.usda.gov/Research/docs.htm?docid=11932). In the last three years it has been tested in the Nebraska State Variety Trials across 39 environments (data available at http://cropwatch.unl.edu/web/varietytest/wheat). NW13493 was not significantly different from all currently popular winter wheat cultivars that were tested state-wide (e.g. Ruth, Freeman, and LCS Valiant). Based upon these data, NW13493 is adapted to all rainfed wheat production areas in NE.

Other measurements of performance from comparison trials indicate that NW13493 is moderately late in maturity which is very similar to Ruth, one day later than Freeman (142.6 d after Jan.1) and two days later than LCS Valiant (141.7 d compared to NW13493 with 143.5 d after Jan.1, n=15). NW13493 is a semi-dwarf wheat cultivar and contains the *RhtB1b* (formerly *Rht1*,). The mature plant height of NW13493 is similar to shorter than Ruth, Robidoux, Overland, and Scout 66. NW13493 is taller than, Freeman, LCS Valiant, Siege, Settler CL, and Wesley (Table 1). NW13493 has moderate straw strength for a semi-dwarf wheat with little lodging reported in the years it has been tested. The winter hardiness of NW13493 is good and comparable to other winter wheat cultivars grown in Nebraska.

NW13493 is resistant to *Soilborne wheat mosaic virus* in field nurseries in Nebraska It is moderately resistant to stem rust (caused by *Puccinia graminis Pers.: Pers. f. sp. tritici* Eriks & E. Henn.) in field nursery tests at St. Paul, MN and moderately resistant to moderate susceptible to stripe rust (caused by *P. striiformis* Westendorp f. sp. t*ritici*) in field nurseries in Nebraska. In greenhouse seedling tests, it is resistant or segregating for resistance to stem rust races QFCSC, QTHJC, MCCFC, RCRSC, RKQQC, and TMPKC, but susceptible to race TTTTF (Table 3). It is moderately resistant to leaf rust (caused by *P. triticina* Eriks,) data obtained from field observations in the Great Plains). By molecular markers, it is believed to carry the Lr37/Sr38/Yr17 translocation. NW13493 is moderately resistant to Fusarium head blight (caused by *Fusarium graminearum*, data from greenhouse and field observations in Nebraska and Kansas) and moderately susceptible to DON accumulation. NW13493 is susceptible to Hessian fly (*Mayetiola destructor* Say,). It is moderately susceptible to *Barley yellow dwarf virus*, and susceptible to *Wheat streak mosaic virus* (data obtained from the USDA-ARS Northern Regional Performance Nursery and field observations in NE).

NW13493 has high grain volume weight which is similar to most high grain volume weight wheats (Ruth and Siege) and significantly higher than Overland, LCS Valiant, Robidoux, and Settler CL (higher grain volume weight cultivars); and Freeman and Wesley, and Scout 66 (lower grain volume weight cultivar). The milling and baking properties of NW13493 were determined for five years by the Nebraska Wheat Quality Laboratory. NW13493 should be acceptable to the milling and baking industries. NW13493 is a white wheat and when conditions were conducive to sprouting, NW13493 retained its high falling number indicating it does not have a preharvest sprout problem.

In positioning NW13493, based on performance data to date, it should be well adapted to most rainfed wheat production systems throughout Nebraska and in adjacent areas of the Great Plains. NW13493 is not recommended for irrigated wheat production due to its not having similar straw strength and comparable yield potential to the best available irrigated wheat cultivars (data not shown**).** Where adapted, NW13493 should be a new white wheat with good end use quality. NW13493 is genetically complementary to virtually all wheat cultivars grown in Nebraska.

NW13493 has been uniform and stable since 2016. Less than 0.5 % of the plants were rogued from the Breeder's seed increase in 2016-19. The rogued variant plants were taller in height (5 - 15 cm) or were awnless and/or had red chaff. Up to 1% (10:1000) variant plants may be encountered in subsequent generations. As with all white wheat cultivars, there is a concern of red kernel contamination. In our fields up to 0.6% red kernels have been found and up to 2% could be encountered in subsequent generations. NW13493 has been licensed to a major milling company.

Development team: P. S. Baenziger (breeder-inventor), R. A. Graybosch, J. Boehm, Jr., D. Rose, M. Guttieri, Lan Xu, S. Wegulo, T. Regassa, A. Easterly, C. Creech, D. Santra, G Kruger, G. Hergert, R. Klein, Y. Jin, J. Kolmer, Ming-Shun Chen, Guihua Bai, J. Poland, I. S. Elbasyoni, G. Hein, and J. Bradshaw.

Grain yield by region and averaged across the state, and state average for grain volume weight, grain protein content, and plant height for Nebraska from 2018 to 2020 representing 39 location-years of data from rainfed environments.

	South East	South Central	West Central	West	State Avg.	State Avg.	State Avg.	State Avg.
Cultivar	Grain Yield (bu/a)	Grain Yield (bu/a)	Grain Yield (bu/a)	Grain Yield (bu/a)	Grain Yield (bu/a)	Bushel Weight lbs/bu	Grain Protein %	Plant Height (in)
	Three Year Averages							
NW13493	86.8	80.1	67	51.6	68.09	57.84	12.87	32.29
Freeman	81	73.4	66	56	67.24	55.69	12.56	31.72
Ruth	86.7	73.4	65.8	57.1	69.21	57.31	12.81	33.19

LCS Valiant	88.7	77.5	70.3	54.3	70.36	57.85	13.14	31.72
Scout 66	62.6	53.7	54.4	42.2	52.34	57.19	13.41	38.21
Turkey	62.7	59.6	55.1	41.4	52.70	57.10	14.24	38.84
Average of all entries†	81.9	73.9	66.7	53.9	66.99	57.14	12.96	32.85
L.S.D. (0.05) ‡	9.3	7.3	4.4	4.3	5.97			

† This value is the average of all the values for the traits for the entries that were in the trial and includes values for many experimental lines not shown in the table.

‡ The L.S.D. (least significant difference $p < 0.05$) was calculated from the analysis of variance using all of the values of the entries that were in the trial including many experimental lines not shown in the table.

NE15420 is a hard red winter wheat selected from the cross 'Hitch/'NW03666'. The pedigree of Hitch (HV9W02-942R) is Bezostaya 1/ Plainsman V sib, (G53)/4/Abilene//(G1113, Sturdy sel./Plainsman V)/3/Karl 92/5/ Jagger/6/(KS89180B, KS8010-73/ KS8010-1-4-2//107349/KS811252/ Karl)' and the pedigree of NW03666 is 'N94S097KS'/'NE93459'. The cross was made in 2009. The F_1 generation was grown at Yuma AZ (row 254) in 2010 and the F_2 to F_3 generations were advanced using the bulk breeding method in the field at Mead, NE in 2011 to 2012. In 2013, single F_3-derived F_4 rows were planted for selection at Lincoln, NE. The $F_{3:5}$ was evaluated as a single four row plot at Lincoln, NE and a single row at Mead, NE in 2014. NE15420 was identified in 2015 as the experimental line, NE15420, and selected for further testing. The only selection thereafter was to remove off types, usually taller plants. This line seems to be narrowly adapted to irrigated production fields in Nebraska. It was selected specifically for irrigated production using both phenotypic and genomic selection.

NE15420 was evaluated in Nebraska replicated yield nurseries starting in 2015 as part of our preliminary yield trial (DUP15) which is grown in an augmented incomplete block design in eight locations in Nebraska and one cooperative location in Kansas. Based on its short plant stature, it was also grown in the Irrigated-Dry Nursery beginning in 2015 (IRDR15) which was grown at three rainfed locations and one irrigated location in an alpha lattice with three replications. In 2015 the line was also genotyped using genotyping by sequencing. Though NE15420 was ranked 59 out of 270 experimental lines in the 2015 preliminary observation nursery, its estimated breeding value was very low, so it was not among the 57 lines that were selected for the advanced yield trial. However, in the IRDR15, the irrigated nursery trial was lost to bad weather, and for the three dryland sites, NE15420 was ranked 14 out of 40 entries so it was advanced to the IRDR16 nursery. In 2016, NE15420 ranked 23 in the average of the three rainfed trials, but third in the irrigated trial (111.4 bu/a) similar to the highest yield line (114.6 bu/a). Thereafter NE15420 was grown in the IRDR nurseries, but the irrigated trial was lost in 2017 and resources prevented an irrigated trial in 2018 and 2019. However, NE15420 was tested in the University of Nebraska Fall Sown Wheat Performance Trials in 2018 to 2020. In the Nebraska IRDR Nursery (2015 to 2020), NE15420 performed as expected with most sites being rainfed. NE15420 was significantly higher yielding than Goodstreak, a tall wheat, not significantly different from Freeman, and significantly lower yielding than LCS Valiant, Ruth, Siege, and Robidoux. As such it was not submitted for testing the USDA-ARS regional nursery program where most trials are rainfed. The grain volume weight was similar to widely grown cultivars, but lower than Siege which is known for its high grain volume weight. For plant height, it was the shortest line in the nursery and it flowers at a time similar to most Nebraska bred cultivars. NE15420 genetically is a semi-dwarf wheat, containing the *RhtB1b* allele (formerly known as *Rht1*). NE15420 has good straw strength for a semi-dwarf wheat cultivar with little lodging reported in the years it has been tested. The winter hardiness of NE15420 is comparable to cultivars commonly grown in Nebraska. In the last three years, it has been tested in the irrigated trials (but again not the rainfed trials) in the Nebraska State Variety Trials across 4 environments (full data available at http://cropwatch.unl.edu/web/varietytest/wheat). NE15420 was the second highest yielding line and not significantly different from WBB418 and WB-Grainfield, Long Branch, AM Eastwood, and CP7869, but was significantly higher yielding than Wesley (a very popular irrigated wheat cultivar known for its strong straw). Its grain volume weight was also good under irrigation, as was its grain protein content. As previously described, it is a short statured wheat under irrigation. The Foundation seed production field performed similarly well under irrigation (data not shown). Based upon these data, NE15420 is adapted to irrigated production, but other cultivars would be recommended for rainfed production.

NE15420 is resistant to *Soilborne wheat mosaic virus* in field nurseries in Nebraska. It is resistant to stem rust (caused by *Puccinia graminis Pers.: Pers. f. sp. tritici* Eriks & E. Henn.) in field nursery tests at St. Paul, MN and moderately resistant to stripe rust (caused by *P. striiformis* Westendorp f. sp. t*ritici*), in field nurseries in Nebraska. In greenhouse seedling tests, it is resistant or segregating for resistance to stem rust races QFCSC, QTHJC, RKQQC, TMPKC, and TTTTF. It is moderately susceptible to leaf rust (caused by *P. triticina* Eriks, data obtained from field observations in the Great Plains). By molecular markers, it is believed to carry the following genes or translocations: *Sbm1, Lr24/Sr24,* and *Lr37/Sr38/Yr17.* NE15420 is moderately susceptible to Fusarium head blight (caused by Fusarium graminearum, data from greenhouse and field observations in Nebraska and Kansas) and moderately susceptible to DON accumulation. NE15420 is susceptible to Hessian fly (*Mayetiola destructor* Say,). Based on genomic data, it is expected to be susceptible to *Wheat streak mosaic virus.*

The milling and baking properties of NE15420 were determined for five years by the Nebraska Wheat Quality Laboratory. NE15420 should be acceptable to the milling and baking industries.

In positioning NE15420, based on performance data to date, it should be well adapted to irrigated wheat production systems in Nebraska. NE15420 is not recommended for rainfed wheat production, except where the grain yields are high enough to mimic irrigated production systems due to other cultivars having superior yield potential in rainfed systems. Where adapted, NE15420 should be a new red wheat with excellent yield potential. NE15420 is genetically complementary to virtually all wheat cultivars grown in Nebraska.

NE15420 has been uniform and stable since 2017. Less than 0.5 % of the plants were rogued from the Breeder's seed increase in 2017-20. The rogued variant plants were taller in height (5 - 15 cm) or were awnless and/or had red chaff. Up to 1% (10:1000) variant plants may be encountered in subsequent generations.

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Grain yield, grain volume weight, plant height, and grain protein content for Nebraska from 2018 to 2020 representing 4 location-years of data from irrigated environments.

	Grain	Grain	Height	Grain
	Yield	Vol. Wt		Protein
Cultivar	(bu/a)	(lbs/bu)	(in)	(%)
WBB418	103.4	56.7	30.5	13.2
NE15420	101.5	57.0	29.5	13.4
WB4303	101.3	55.6	30.3	13.8
NHH144913-3	99.3	55.7	32.5	13.1
WB-Grainfield	98.0	56.8	29.4	13.1
Long Branch	97.8	57.2	30.4	12.5
AM Eastwood	97.8	57.2	29.3	13.7
CP7869	97.5	56.9	27.4	13.1
Wesley	94.2	56.4	30.1	13.8
SY Sunrise	93.5	57.9	29.4	13.2
Siege	89.1	57.1	29.8	13.9
Robidoux	86.3	53.6	27.4	14.4
Mean	96.9	56.5	29.6	13.4
LSD 0.05*	4.67	0.99	1.26	0.45

IV. FIELD RESEARCH

1. Increase of New Experimental Lines

With the licensing of NW13493 and the release of new variety NE15420, Husker Genetics Brand Ruth, NuPride Genetics Siege, LCS Valiant, Freeman, Goodstreak, Panhandle, Robidoux, and Settler CL over the past several years, most advanced current breeding lines are not expected to be released. However, a number of lines are targeted for advancement or possible release in 2021 or shortly thereafter. Specifically, the following lines are under large scale increase:

Species	Line	Pedigree	Comment	Expected Release
Barley	NB15420	P-845/NB08410	Excellent Grain Yield	2021-22
	NB10425	ND17687/SC010475=(VA75-4-24/SC793556//CIho2457 (hulless))	Excelletn Grain Yield	2021
Triticale	NT13443	04TG 112/NE422T=(TRICAL /UB-UW26)//NE03T40	Excellent forage and grain yield	2021
	NT12404-1	NT04432=(NE92T422(=COMPLEX)/TX95VT7117)/ NT05434=(NE98T424 (=PRESTO/NE91T409)?PLAI(1998 INTRODUCTION))	Excellent grain with fair forage yield	2021-22
	NT14433	Haiduc/NE426GT//NT06427	Excellent forage yield	2021-22
Wheat	NE16562	HV9W02-942R/CAMELOT	High yielding semidwarf line	2021-22
	NHH17450	Brawl_CL/NHH09655	BASF approved CL plus semidwarf line	2021-22
	NHH17612	Brawl_CL/NHH09655	BASF approved CL plus semidwarf line	2021-22

Disease and Insect Resistance Characteristics of current and future wheat lines:

Name	Sr	LR	YR	HF	SBMV	D. Bunt	Acid Soil	PEDIGREE
Freeman	MR	MS	MR	SEG	R			KS92-946-B-15-1=(ABI86*3414/JAG//K92)/ALLIANCE
LCS Valiant	MR	MR	S	MR	R			NI03418/Camelot
NE14696	MR	MR/MS	MR	S	R			NE05537/Overland
NE15420	R	MS	MS	S	R			HV9W02-942R/NW03666
NE15624	MS	MS	MR/MS	S	R	S		NE05537/KS05HW15-2
NE16562	R	MR	S	R	R			HV9W02-942R/CAMELOT
NE16563V	R	MR	MR	S	R			NW07534/Hitch
NE17441	R	MR/S	MR	S	R	S	S	Hitch/NE07409
NE17443	R	MS	S	S	R	S	MS	NW07534/NE06545
NE17544	R	MS	MR	MR/MS	S	S	S	Pan3349/HV9W04-1594R//NE06607
NHH17450	R/MS	S	MR/MS	S	R	MR/MS	R	Brawl_CL/NHH09655
NHH17612	R/MR	MS	MR	S	Het.	MR/MS	R	Brawl_CL/NHH09655
NW13493	R/MR	MR	MR/MS	S	MR	S		SD98W175-1/NW03666
NW15443	R	S	MS/S	MR/MS	R/S			OR 2060108/NW03681//NW03666
Overland	MR	R	S	S	R?	S		Millennium sib//ND8974 (=Seward/Archer)
Panhandle	MR	MS	S	S	MR			NE97426 (=BRIGANTINA.2*ARAPAHOE)/NE98574
PSB13NEDH-14-83W	MR	MR	MR	R	R			NW03681/ SD07W084
Robidoux	MR	MS/S	MR	S	R			NE96644/Wahoo-sib
Ruth	MR	S	MR	MR	R		MS	OK98697/Jagalene//Camelot
Siege	MR	MS	MR	MR	R	S	MS	NI04420/NE00403
Wesley	R	S	MS/S	S	R			KS831936-3//COLT/CODY

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

In 2020, we increased NT13443 (winter triticale) and NB15420 (winter barley) with the intention to formally release them in 2021 or 2022.

NT13443 was selected from the cross ‘04TG 112’/’NE422T’= (TRICAL /UB-UW26)//NE03T407) which was made in 2007. The pedigree of N03T407 is Trical102/NT94T416. The pedigree of NT96T416 is ‘LT602/81’/OAC-85-16// NT87T148. The F_1 generation was grown in the greenhouse in 2008 and the F_2 to F_3 generations were advanced using the bulk breeding method in the field at Lincoln, NE in 2009 to 2010. In 2011, 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, NE in 2012. NT13443 was identified in 2013 as the experimental line, NT13443, and selected for further testing in multilocation trials (Lincoln, Mead, and Sidney, NE). Thereafter it was tested in multilocation replicated trials at the same three NE locations.

NE13443 was evaluated in Nebraska replicated yield nurseries starting in 2013 as part of our preliminary yield trial which is grown in an augmented incomplete block design in three locations in Nebraska (Lincoln, Mead [two replications], and Sidney). In 2014 to 2016 and 2018, it was grown in our triticale elite nursery which was grown at the same three locations in a three replicate alpha lattice design and in the triticale forage trial which used four replications and an alpha lattice design. In those trials (Table 1), four cultivars and one experimental line were used for comparison. NT06427 is a short awned triticale which is used for grain or forage production. Short awns or awnless cultivars are preferred for haying triticale lines. NT07403 and NT09423 were released primarily for their superior grain yield. NT14433 is an advanced experimental line that is targeted for forage production. NT441 is our most popular forage triticale cultivar. NT13443 was a medium maturity triticale cultivar (5 days earlier than the popular NT441, similar to NT09423, and 5 days later than NT07403). NT13443 is a tall cultivar similar to NT441 and the experimental line NT14433 and taller than the grain triticale cultivars

(NT09423, NT07403, and NT06427). For grain yield, NT13443 was not significantly different from the cultivars specifically released for grain yield (NT09423 and NT07403, and NT06427) and the experimental forage line NT14433, but significantly higher yielding than NT441. For grain volume weight, NT13443 was similar to most triticale lines and superior to NT06427. For forage yield harvested shortly after flowering, NT13443 was significantly higher yielding than most grain triticale lines, but not significantly different from NT07403 (due to a very high CV in that comparison) or the forage triticale cultivar and experimental lines. What is exceptional about NT13443 is that has a similar forage yield as the popular NT441, but has an almost 50% higher grain yield, hence for seed producers of forage triticale cultivars, this should greatly reduce the cost of seed production and increase their profitability.

NT13443, like most winter triticale cultivars in Nebraska, is moderately resistant to leaf (caused by *Puccinia triticina* Eriks), stem (caused by *P. graminis Pers.: Pers. f. sp. tritici* Eriks & E. Henn.), and stripe (caused by *P. striiformis* Westendorp f. sp. *tritici*) rust. The major disease on triticale is bacterial leaf streak (caused by *Xanthomonas campestris* pathovar (pv.) *undulosa*) and NT13443 is similar to the comparative cultivars (moderately susceptible). The other major disease is ergot (caused by *Claviceps purpurea* (Fr.) Tul.) and NT13443, as all Nebraska developed triticale cultivars was selected for low ergot infection rates, hence would be considered moderately resistant. NT13443 has a level of winter hardiness similar to the currently released winter triticale cultivars which is lower than winter hardy wheat and superior to winter hardy barley.

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Acknowledgements: Critical technical support came from Greg Dorn and Mitch Montgomery.

Head-to-head comparisons of NT13443 to popularly grown or new cultivars from trials in Nebraska beginning in 2014 to 2016 and in 2018. The comparative cultivars NT06427, NT07403, and NT09423 are primarily grain triticale cultivars. NT441 is our most popular forage triticale cultivar. NT14433 is an advanced experimental line targeted for forage production. Data on grain yield, grain volume weight, plant height, and anthesis date were from trials at up to three locations (Mead, Lincoln, and Sidney) in Nebraska in each year (total environments in the comparison is N) and not every cultivar was grown in the same trial across the state. Forage yield trials were at Mead, Nebraska only.

		Anthesis Date				Height				Grain Yield				Grain Volume Weight				Forage Yield		
		D after Jan. 1				cm				kg/ha				kg/hl				lbs/a		
	N	Line	NT13443		N	Line	NT13443		N	Line	NT13443		N	Line	NT13443		N	Line	NT13443	
NT06427	7	144.2	145.5	**	10	117.7	145.1	**	10	6271	6478	n.s.	4	58.8	64.4	**	4	11000	12963	*
NT07403	7	140.7	145.5	**	10	115.9	145.1	**	10	6682	6478	n.s.	4	63.5	64.4	n.s.	4	9925	12963	n.s.
NT09423	7	145.4	145.5	n.s.	10	121.2	145.1	**	10	6478	6478	n.s.	4	62.6	64.4	n.s.	4	11529	12963	*
NT14433	5	143.3	144.0	n.s.	7	146.2	146.0	n.s.	7	5150	6014	n.s.	4	65.2	64.4	n.s.	3	11853	12089	n.s.
NT441	5	149.2	144.0	**	7	144.2	146.0	n.s.	7	4034	6014	*	4	60.9	64.4	n.s.	3	11265	12089	n.s.

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

NB15420 was selected from the cross P-845/NB08410. The pedigree of P-845 is Dictoo/NE91709, and the pedigree of NB08410 is NE95711/Legacy//NE95711 where Legacy Barley is a 6-row malting barley developed by Busch Agricultural Resources. The cross was made in 2009. The F_1 generation was grown in the greenhouse at Lincoln in 2010, and the F_2 to F_3 generations were advanced using the bulk breeding method in the field at Lincoln, NE in 2011 to 2012. In 2013, single F_3-derived F_4 head-rows were planted for selection at Lincoln, NE. The $F_{3:5}$ was evaluated as a single four row plot at Lincoln, NE in 2014. NB15420 was identified in 2015 as the experimental line, NB15420, and selected for further testing. The only selection thereafter was to remove off types, usually taller plants or plants with different head characteristics. This line seems to be broadly adapted to rainfed production fields in the central Great Plains.

NB15420 was evaluated in Nebraska replicated yield nurseries starting in 2015 as part of our preliminary yield trial (BDUP15) which was grown in an alpha-lattice incomplete block design with two replications in three locations in Nebraska (Lincoln, Mead, and Sidney). Based on its agronomic performance, it was advanced in 2016 to our barley elite trial which was grown using an alpha-lattice incomplete block design with three replications at the same three locations in Nebraska and also at Colby or Hays, KS. NB15420 was tested in the barley elite trial thereafter, with an additional testing location being added at Stillwater OK in 2017 for a total of five testing locations. Due to severe winters and storms, barley yield trials are often lost. The two comparison cultivars are P-954 and P-845. Historically P-954 is one of the most winter hardy barleys in the central Great Plains and P-845 was a high yielding more recent release (2013). In these trials, NB15420 was similar for winter survival to both P-845 and P-945 (data not shown). NB15420 was similar in flowering to P-845 and 4 days earlier than P-954. It was similar to P-954 in plant height and one inch taller than P-845. For grain yield, NB15420 (3974 lbs/a, 82.8 bu/a) was significantly higher than P-845 (3636 lbs/a, 75.8 bu/a) and P-954 (3491 lbs/a, 72.8 bu/a). For grain volume weight, NB15420 was not significantly different from P-845 or P-954.

In 2018-19, it was entered into the USDA-ARS Uniform Winter Barley Trial where it ranked 6th out of 18 entries (data available at: https://www.ars.usda.gov/southeast-area/raleigh-nc/plant-science-research/docs/nursery-reports/page-2/). As the data came mainly from the Southeastern USA, the line performed well for being so far from home. Barley diseases are relatively rare in Nebraska with winter survival being the major concern, so limited disease information is available. However data from the USDA-ARS Uniform Winter Barley Trial indicate that NB15420 is susceptible to stripe rust (incited by *Puccinia striiformis* f. sp. *hordei*) and moderately susceptible to Fusarium head blight (incited by *Fusarium spp.*) In 2020, a season where the yield trial at Mead was severely damaged and delayed by winter injury, NB15420 was also susceptible to late onset stem rust (incited by *P. graminis* f. sp. *tritici*). In Nebraska, winter barley has a normal growth pattern where it escapes *P. graminis* infection.

In positioning NB15420, based on performance data to date, it should be well adapted to rainfed barley production systems in Nebraska, Kansas, and Oklahoma. As P-845 is a parent of NB15420, NB15420 and P-845 should be considered as genetically similar and both should not be grown together if the goal is to add diversity to the barley crop.

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Head to head comparisons of NB15420 to P-954 and P-845 from trials in Nebraska and Kansas beginning in 2016, and Nebraska, Kansas, and Oklahoma from 2017 to 2020. Data on anthesis date, plant height, grain yield and grain volume weight from trials at three locations (Mead, Lincoln, and Sidney) in Nebraska, Hayes KS or Stillwater OK (total environments in the comparison is N).

		Anthesis Date				Height				Grain Yield				Grain Volume Weight		
		D after Jan. 1				in				lbs/a				lbs/bu		
	N	Line	NB15420		N	Line	NB15420		N	Line	NB15420		N	Line	NB15420	
P-845	11	133.2	132.7	n.s.	14	33.8	34.91	*	15	3636.00	3974	**	7	45.6	46.8	n.s.
P-954	11	136.2	132.7	**	14	34.14	34.91	n.s.	15	3491.00	3974	**	7	47.4	46.8	n.s.

*, **, n.s. Significantly different at the P=0.05, P=0.01 probability level or not significantly different.

Other lines under early stages of increase include: NT14433, a new tall triticale for the forage market. NT14433 is a very tall triticale similar to NT441, a very popular forage triticale, but with better grain yield and forage yield than NT441. NT14433 was derived from the cross Haiduc/NE426GT//NT06427 where Haiduc was a triticale parent line from Rumania, NE426GT was an early released grain triticale, and NT06427 was a released awnletted triticale. NT14433 is a very tall (similar to NT441), medium maturity (~4 days earlier than NT441), exceptionally high yielding forage triticale (slightly better than NT441) with a lower grain yield when compared to our grain triticales, but superior to NT441 (~19% higher yielding than NT441) as is often the case with forage triticales. Its standability is good for a tall triticale. It is resistant to most common diseases and insects of wheat as are most triticale lines with the exception of bacterial streak and ergot. NB10425 is a good, hulled winter barley line that was increased when we were working with Paramount seeds. It was derived from the cross: ND17687/SC010475= (VA75-4-24/SC793556//CIho2457 (hulless)). In the years of testing it was 7% better than both P-845 and P-954 in eight trials. It is two inches taller than the two lines and also tends to have higher test weight.

In 2020, two advanced lines, NHH17450 and NHH17612 were approved by BASF for commercialization if they meet the agronomic expectations for new wheat cultivars. Both are in the 2020 the SRPN nursery and NHH17612 is also in the 2020 NRPN (had sufficient seed) and are derived from the cross: Brawl CLplus/NHH09655. The SRPN and NRPN reports for 2020 are incomplete, In the SRPN20, NHH17450 ranked 27 and NHH17612 ranked 30 out of 50 tested lines. This was not a surprise as most of the reporting stations were south of Nebraska and early maturing lines did better due to heat and drought. In the NRPN20, NHH17612 ranked 26 out of 41 lines. Finally, we also send NE16562 to Yuma AZ for initial seed increase. NE16562 was derived from the cross Hitch (=HV9W02-942R)/CAMELOT. It was entered in the SRPN and NRPN in 2019 where it ranked 7th out of 49 entries and 9th out of 48 entries respectively and in the SRPN and NRPN in 2020 where it ranked 37 out of 50 entries and 22 out of 42 entries respectively.

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

Numerous entries were included in some or all of the locations in the Fall Sown Small Grain Variety Tests in 2020. The overall data are listed below. Lines such as Ruth and LCS Valiant which did well are broadly adapted across Nebraska. Other lines are adapted to specific parts of the state, but not necessarily the whole state. The yield of Wesley was a surprise. The yield of NHH144913-3 was 43% higher than Scout 66. The yield of Ruth was 39% higher than Scout 66.

Name	Name Alternate	Brand/Source	Yield (bu/ac)		Test Weight (lb/bu)		Height (in)		Protein (%)	
			Average	SD	Average	SD	Average	SD	Average	SD
NHH144913-3		UNL	61.5	20.9	54.3	2.8	31.1	3.6	13.6	1.0
Wesley		UNL	61.2	21.3	57.1	3.3	30.0	3.7	13.6	1.2
CP7869		CROPLAN by WinField United	61.1	19.9	57.8	3.4	29.3	3.4	12.7	1.1
NW13493		UNL	59.9	24.2	57.3	3.8	30.4	4.0	13.3	1.0
CP7017AX		CROPLAN by WinField United	59.9	20.9	56.9	3.1	28.6	3.1	12.7	0.9
Ruth		UNL	59.4	22.1	57.3	3.7	31.2	4.4	13.3	1.3
LCS Valiant		Limagrain Cereal Seeds	58.3	20.1	57.3	3.4	29.4	3.2	13.6	1.6
Long Branch		Dyna-Gro Seed	57.7	22.0	56.2	3.5	29.6	4.0	12.9	0.9
CP7010		CROPLAN by WinField United	57.5	19.7	58.5	3.3	28.9	2.8	13.2	0.8
NE15624		UNL	55.9	20.0	57.1	3.0	28.8	3.7	13.7	1.1
NE14434		UNL	55.5	21.4	55.3	4.1	31.5	4.4	13.3	1.1
Freeman		UNL	55.4	19.1	55.3	3.0	30.0	4.0	13.3	1.1
Siege	NE12561	UNL	54.6	19.7	57.9	3.8	30.1	3.9	14.0	1.0
CP7050AX		CROPLAN by WinField United	53.9	16.4	58.0	3.2	29.3	3.3	14.1	1.3
CP7909		CROPLAN by WinField United	53.5	19.8	57.4	3.2	28.6	3.8	12.8	1.2
NE16562		UNL	52.3	19.4	54.9	4.6	29.4	3.6	13.7	1.0
Turkey		NA	44.5	15.9	56.4	2.7	36.7	6.1	14.6	1.1
Scout 66		NA	42.8	14.7	56.2	2.7	35.9	4.9	13.8	1.2

The overall data for 2019 are listed below. Lines such as LCS Valiant which did well are broadly adapted across Nebraska.

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

Nine dryland locations in Nebraska were harvested for yield data and the data for the top ten lines grown across the state in 2018 are presented below.

Name	Average
LCS Valiant	78.3
SY Monument	77.2
WB-Grainfield	76.9
NW13493	76.7
LCS Link	76.3

NHH144913-3	75.3
NI13706	75.0
LCS Chrome	74.8
Long Branch	74.3
SY Wolf	74.0
Ruth	73.8
WB4418	73.5
NE12561	73.1
AM Eastwood	72.7
NE13515	72.4
Freeman	70.9
Turkey	60.4
Scout 66	58.2

3. Irrigated Wheat Trials:

In 2020, two irrigated trial were harvested (Box Butte County and Chase County). The data for 2020 can be found at: https://cropwatch.unl.edu/winter-wheat-variety-test-results and are presented below. The data are courtesy of A. Easterly and C. Creech.

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Irrigated
2020 Winter Wheat Variety Trial Averages

Name	Company	Average Yield (bu/ac)[1]	Average Test Weight (lb/bu)
Canvas	PlainsGold	106.8	61.0
WB4595	WestBred	104.1	61.3
LCS Valiant	Limagrain Cereal Seeds	103.0	60.7
Monarch	PlainsGold	102.9	59.9
Long Branch	Dyna-Gro Seed	102.4	59.5
WB4303	WestBred	101.7	57.2
CP7017AX	CROPLAN by Winfield United	101.7	60.1
WB4418	WestBred	101.2	58.8
CP7869	CROPLAN by Winfield United	101.2	58.7
Wesley	Husker Genetics	99.0	59.0
WB-Grainfield	WestBred	98.4	59.0
CP7909	CROPLAN by Winfield United	98.2	59.1
WB4699	WestBred	98.2	57.9
SY Sunrise	AgriPro-Syngenta	96.9	59.3
CP7050AX	CROPLAN by Winfield United	96.8	60.5
NHH144913-3	UNL-Experimental	96.8	57.2
SY Wolverine	AgriPro-Syngenta	96.5	59.4
CP7010	CROPLAN by Winfield United	96.5	59.9
NE15420	UNL-Experimental	95.1	59.1
NE15624	UNL-Experimental	93.9	59.3
Breck	PlainsGold	93.7	61.0
AM Cartwright	AgriMaxx Wheat Company	91.5	59.2
AM Eastwood	AgriMaxx Wheat Company	90.4	58.9
WB4792	WestBred	89.3	60.0
LCS Link	Limagrain Cereal Seeds	88.4	59.7
Robidoux	Husker Genetics	84.6	58.4
NE14434	UNL-Experimental	83.7	58.6
Siege	NuPride Genetics	83.1	58.8
Turkey	Check	70.1	56.9
Scout 66	Check	62.4	57.9

[1] Yield values corrected to 12% moisture.

The data for 2019 are:

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

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

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

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

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

In 2017, due to financial restraints we had to drop the experimental line irrigated nursery. However, we went with a commercial grower in 2020. Due to what was thought to be winterkilling the yields were low, but still useful. We are able to continue our dryland nursery and work with the commercial grower for the irrigated trial. The selected lines should have better straw strength and shorter plant height. The goal of this nursery is to identify higher yielding lines under irrigation and under higher rainfall conditions, which periodically occur in Nebraska.

The data for 2020 are:

	Linc.	N.Platte	Alliance	Grant IR	AverageDry	Rank	AverageAll	Rank4
Name	bu/a	bu/a	bu/a	bu/a	bu/a		bu/a	
PSB13NEDH-14-83W	67.3	61.1	43.5	54.2	57.3	1	56.5	1
NE19590	67.1	55.9	43.3	56.5	55.4	2	55.7	3
NE17662	72	58	35.5	54.2	55.2	3	54.9	6
NE16468	67.5	60.2	34.4	49.2	54.0	4	52.8	15
NE19430	69.1	56	36	49.7	53.7	5	52.7	16
LCS LINK	62.3	58.3	40	54.4	53.5	6	53.8	9
NE19617	67.3	52.7	39.7	52.5	53.2	7	53.1	12
LCS Valiant	65	59.9	34.5	60.1	53.1	8	54.9	7
NE19523	68.9	56.9	33.2	65.7	53.0	9	56.2	2
NE19466	65.2	62	31.6	62.4	52.9	10	55.3	4
NE19611	67.8	59.8	30.8	56	52.8	11	53.6	10
NHH19655	65.3	56.3	36.5	53.8	52.7	12	53.0	14
NE19471	60.6	59.8	35.9	55.6	52.1	13	53.0	13
NE17483	62.4	56.8	36.3	58.4	51.8	14	53.5	11
NHH19668	61.6	62.5	31.1	65.8	51.7	15	55.3	5
NE19451	62.7	52.6	39.3	54.4	51.5	16	52.3	18
NE17534	63.5	55.7	35.3	49.2	51.5	17	50.9	23
NE19473	61.7	56.6	35.6	53.2	51.3	18	51.8	19
NE19547	57.6	59.7	36.3	52.8	51.2	19	51.6	20
NE19403	59	56.5	37.5	45.1	51.0	20	49.5	29
NE16562	59.2	63	30.7	62.9	51.0	21	54.0	8
NE19589	56.6	55.7	38.9	49.8	50.4	22	50.3	26
NE19605	56.6	55	39.6	54.3	50.4	23	51.4	21
NE19421	59.5	54.6	36.7	45.2	50.3	24	49.0	35
NHH19670	60.2	56.4	34	46.9	50.2	25	49.4	30
NE17620	58.1	59.9	31.9	48.9	50.0	26	49.7	28
NE19615	63.8	52.3	33.8	53.3	50.0	27	50.8	24
NE19431	64.6	52.7	32.1	61.1	49.8	28	52.6	17
NE19441	55.3	55	38.8	41.8	49.7	29	47.7	37
NE17544	65.8	50.8	31.3	49.3	49.3	30	49.3	32
NE16424	54.9	61	31.3	53.2	49.1	31	50.1	27
NE15420	60.9	56.8	29.2	55.8	49.0	32	50.7	25
NE19544	62.5	50.3	33.1	51.2	48.6	33	49.3	33
NE17589	61.5	51.5	30.1	44.9	47.7	34	47.0	40
NE19533	60	56.6	25.6	47.9	47.4	35	47.5	39
NE19458	59.7	54.2	26.1	55	46.7	36	48.8	36
NE19478	59.1	53.1	27.5	57.3	46.6	37	49.3	34
NE19483	56.3	45.9	37.4	51.1	46.5	38	47.7	38
NE19460	51.4	54.6	31.3	60	45.8	39	49.3	31
NE19455	56.6	54.1	26.5	66.7	45.7	40	51.0	22
GRAND MEAN	61.91	56.27	34.31	53.99				
LSD	7.77	5.78	10.89	12.57				
CV	7.67	5.25	16.24	11.91				
Heritability	0.37	0.55	0.22	0.35				

The data for 2019 are:

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

The data for 2018 are:

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

The three-year averages for the lines tested in all three years (2018-2020) are below. Note very few lines were in common for all three years.

	Name	Linc. Yield bu/a	N.Platte Yield bu/a	Alliance Yield bu/a	St. Avg. Yield bu/a	Rank	Flowering Date D after 1/1	Height (in)	Test Weight (lbs/bu)
2018-20	**NE17544**	76.7	55.4	64.1	65.4	1	148.8	36.9	57.8
2018-20	**NE17620**	75.1	60.4	60.4	65.3	2	148.5	33.8	58.5
2018-20	**NE17662**	82.5	53.6	58.0	64.7	3	148.1	35.9	58.0
2018-20	**NE17589**	74.3	56.1	62.1	64.2	4	147.1	33.7	56.7
2018-20	**LCS Valiant**	71.6	58.0	62.4	64.0	5	145.7	31.8	58.4
2018-20	**NE17534**	73.6	58.5	59.6	63.9	6	147.0	31.7	58.3
2018-20	**NE15420**	73.2	50.5	56.2	60.0	7	146.1	32.3	57.3
2018-20	**NE16562**	60.3	58.5	58.2	59.0	8	144.8	37.0	58.3

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

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

In 2020, Nebraska Intrastate Nursery (NIN) was planted at eight locations in Nebraska: Lincoln, Mead, Clay Center, McCook (added due to generous support from Ardent Mills), North Platte, Grant (added due to a generous gift from Marvin Stumpf), Sidney, and Hemingford (syn. Alliance). In addition, two replications at Lincoln were sprayed once with fungicides to control fungal disease, while two replications were not treated which allowed a comparison of fungal diseased vs. largely fungal disease free genotypes. Fungicides do not control bacterial or viral diseases. The improvement due to fungicide application was 6% or 3.6 bu/a. As mentioned earlier, fungal disease pressure was not high at Lincoln in 2020.

	MEAD	LINC.IM	Linc	CLAY CEN	NPLATTE	MCCOOK	GRANT	SIDNEY	ALLIANCE	**NE**	
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	**AVERAGE**	RANK
Name	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	**bu/a**	
NI13706	58.1	68.5	61.5	64.0	53.9	69.0	38.7	39.0	53.0	**56.19**	1
NE13425-1	54.4	69.6	65.9	65.0	50.7	68.4	37.6	32.4	45.1	**54.34**	2
NE16562	47.1	68.0	63.4	65.5	53.7	61.5	39.2	37.2	43.0	**53.18**	3
PSB13NEDH-14-83W	51.8	65.5	62.4	64.2	52.6	63.6	36.8	33.9	41.7	**52.50**	4
NE13434-1	53.5	63.1	59.2	55.3	53.5	66.2	43.7	35.2	41.2	**52.32**	5
NE18573	49.9	69.1	63.2	62.9	47.3	58.5	41.7	37.9	37.1	**51.96**	6
NE18455	47.0	64.4	66.1	54.1	54.2	56.8	37.4	39.7	47.7	**51.93**	7
NW13493	53.8	65.4	61.3	63.2	48.9	59.3	34.4	36.0	43.4	**51.74**	8
NE16468	53.8	60.4	52.0	64.8	51.0	60.8	41.3	41.4	39.9	**51.71**	9
Ruth	55.4	69.0	60.1	62.4	49.8	58.3	35.8	23.9	49.7	**51.60**	10
NE14494	56.4	68.9	60.2	62.8	48.1	60.7	31.2	31.6	42.3	**51.36**	11
NE18445	53.8	64.6	55.5	56.9	49.2	60.8	40.4	29.8	46.9	**50.88**	12
NE18435	45.3	58.8	61.4	59.8	51.1	58.8	39.5	35.6	45.9	**50.69**	13
NE17544	51.1	62.3	56.3	64.1	49.3	48.6	34.0	41.3	47.9	**50.54**	14
NE18630	55.4	64.3	63.6	54.8	45.2	60.3	30.4	37.9	41.6	**50.39**	15
NHH17612	56.9	56.6	54.3	58.5	55.7	62.0	42.0	29.3	37.1	**50.27**	16
NE18625	55.0	64.9	64.9	56.8	49.9	58.4	37.6	28.5	35.4	**50.16**	17
NE17626	55.3	58.9	49.6	66.2	48.8	56.3	37.1	38.7	39.8	**50.08**	18
NW15443	53.9	53.9	59.0	59.3	47.4	61.5	33.1	38.1	42.7	**49.88**	19
NE15624	46.3	65.2	54.2	53.7	53.3	59.5	43.3	35.2	37.8	**49.83**	20
LCS Valiant	50.7	53.5	61.0	53.7	49.5	63.3	47.8	30.5	36.9	**49.66**	21
NE18640	56.1	59.7	59.5	56.2	49.2	61.6	37.8	25.8	39.4	**49.48**	22
NW13570	47.2	66.6	62.3	63.8	47.7	58.5	31.0	33.4	34.3	**49.42**	23
NHH17450	48.6	57.2	55.0	59.9	54.0	60.0	32.0	36.9	40.5	**49.34**	24
NE16424	45.8	57.5	53.7	58.9	50.7	60.6	37.0	34.4	43.1	**49.08**	25
NI17410	41.6	61.1	54.0	57.4	51.2	61.0	39.4	37.8	37.9	**49.04**	26
NE18544	49.5	66.0	59.4	60.4	48.8	55.6	34.1	28.8	38.2	**48.98**	27
NE18472	57.8	65.8	47.8	59.2	46.2	58.1	36.1	30.7	38.0	**48.86**	28
NE16563V	46.0	61.9	57.4	57.7	48.6	56.1	37.9	35.5	37.5	**48.73**	29
GOODSTREAK	59.8	60.5	63.0	56.3	44.2	54.2	32.9	28.1	38.8	**48.64**	30
Panhandle	46.8	63.3	54.5	55.9	44.2	57.8	33.3	33.5	48.1	**48.60**	31
NE17443	45.5	56.5	58.5	55.5	49.4	54.4	42.5	31.9	42.7	**48.54**	32
Robidoux	53.3	60.9	58.9	59.4	50.3	49.8	32.0	30.3	41.0	**48.43**	33
NE18583	47.3	58.0	56.7	53.2	49.8	61.8	36.8	33.3	37.6	**48.28**	34
NE17441	37.2	50.1	57.0	57.3	50.1	61.9	41.1	34.0	44.8	**48.17**	35
NE18644	46.8	66.4	52.5	51.9	49.4	63.2	34.0	31.6	37.5	**48.14**	36
NE15410	44.7	62.6	60.1	61.2	49.9	59.6	32.0	28.5	32.0	**47.84**	37
NE17442	40.4	57.5	48.8	57.0	53.9	62.1	38.1	34.7	37.2	**47.74**	38
NE14434	59.6	63.2	58.9	58.0	43.3	52.3	33.4	24.7	36.2	**47.73**	39
NE18517	47.9	65.0	54.7	52.0	47.2	52.2	33.9	33.1	43.5	**47.72**	40
NE18562	48.7	62.4	60.9	54.1	44.6	53.0	26.1	40.8	38.1	**47.63**	41
NE18469	48.9	56.9	51.8	57.6	47.1	59.9	38.1	27.2	40.6	**47.57**	42
NI17411	47.0	56.0	55.6	58.1	44.3	58.1	36.5	27.3	44.4	**47.48**	43
NE18509	47.3	59.1	56.4	55.1	45.7	56.0	35.9	26.8	44.8	**47.46**	44
NE18412	45.8	59.3	57.3	55.0	46.2	57.1	35.7	29.5	40.8	**47.41**	45
NE17470	49.8	57.5	54.8	54.9	42.2	50.7	34.7	36.0	43.0	**47.07**	46
NE17534	52.8	59.0	57.8	45.2	51.1	55.8	33.6	26.1	41.6	**47.00**	47
NE18434	45.5	51.0	59.3	56.6	50.0	51.0	38.2	29.3	42.1	**47.00**	48
NE17572	46.3	61.8	57.4	57.6	37.1	52.2	38.2	28.0	40.7	**46.59**	49
NE17462	44.7	56.1	50.9	58.3	49.3	55.4	34.0	34.7	35.0	**46.49**	50
Freeman	44.9	63.1	51.5	52.3	44.4	49.8	33.9	33.9	43.5	**46.37**	51
NE14696	52.4	59.3	54.0	55.6	43.7	50.8	31.5	26.7	40.9	**46.10**	52
NE17433	44.6	60.9	54.9	57.5	42.2	46.2	26.5	34.5	36.1	**44.82**	53
NE17576	46.6	53.2	52.4	52.5	40.3	59.0	28.8	33.9	36.2	**44.77**	54
NE17589	49.3	57.0	57.4	59.8	42.9	47.1	29.1	21.5	36.6	**44.52**	55
Siege	38.5	54.5	50.9	53.4	46.3	54.5	32.4	32.3	36.1	**44.32**	56
NE18466	44.6	51.6	50.6	46.7	41.7	52.8	28.0	38.1	41.5	**43.96**	57
NE14691	42.4	57.8	52.7	50.9	41.1	50.9	33.7	30.7	32.1	**43.59**	58
SCOUT66	44.7	46.9	41.3	43.7	37.2	45.2	33.3	23.0	39.1	**39.38**	59
CHEYENNE	43.2	40.2	46.3	44.9	36.4	53.0	29.4	25.8	33.1	**39.14**	60
Mean	**49.2**	**60.3**	**56.7**	**57.2**	**47.8**	**57.2**	**35.6**	**32.4**	**40.5**	**48.5**	

In 2019, at Lincoln, the untreated plots yielded 18% less than the fungicide treated plots (an average of 14.7 bu/a) in a year when disease was normal compared to previous years. Note the benefit of the fungicide application varied considerably with the line. Data for 2019 are:

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

In 2018, Nebraska Intrastate Nursery (NIN) was planted at eight locations in Nebraska: Lincoln, Mead, Clay Center, McCook (added due to generous support from Ardent Mills), North Platte, Grant (added due to a generous gift from Marvin Stumpf), Sidney (lost to severe storms the day we began harvesting the site) , and Hemingford (syn. Alliance). The 2018 data are:

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

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

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

There were significant differences in milling performances among these cultivars. The flour, bran and short yields were 72.9±0.9%, 34.2±1.7%, and 3.1±0.5%, respectively. All samples got high flour yield (>70.0%) including the checks. The bran, short and milling rates were 3.7±0.5, 3.3±0.6, and 3.3±1.1, respectively. Most samples got fair or better bran cleaning and milling performance.

The kernels hardness indexes were significantly positively with short yields, bran cleaning and milling performances as well as wheat protein and ash contents. The kernels diameters were significantly positively with kernels weights, and short yields. In addition, the flour yields were significantly positively with bran cleaning and milling performances as well as wheat protein contents, and negatively with brain yields. The bran yields were significantly negatively with bran cleaning and milling performances as well as wheat protein contents. The short yields were significantly positively with ash contents and negatively with short cleaning rates. The bran cleaning rates were significantly positively with short cleaning and milling performance rates as well as wheat protein contents. The short cleaning rates were significantly positively with milling performance rates.

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

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

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

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

Data from 2018 to 2020 (three year average) from the Nebraska Intrastate Nursery for grain yield (bu/a) are presented below:

Name	Mead	Linc.IM	Linc.	C.Center	N.Platte	McCook	Grant	Sidney	Alliance	State	Rank	Test	Hdate	Height
	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Average		weight	Julian	
Name	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a	bu/a		lbs/bu	After Jan.1	In
NE16562	45.4	81.7	77.0	70.6	53.8	75.3	60.9	48.9	64.1	66.7	1	58.0	145.0	26.9
NI13706	43.0	78.3	68.2	65.4	55.5	73.2	63.6	50.3	64.5	65.1	2	58.7	148.9	28.4
NE16468	44.2	79.1	66.6	66.5	55.8	73.0	58.6	50.3	61.7	64.3	3	57.7	146.7	27.1
PSB13NEDH-14-83W	40.6	80.7	67.0	59.0	57.6	75.5	62.1	42.2	60.9	63.4	4	59.3	148.6	28.3
NE16424	41.6	73.5	68.4	61.4	51.5	75.0	62.9	48.1	62.7	63.1	5	58.6	146.5	25.8
NW13493	47.2	75.1	69.9	66.3	48.2	72.9	62.1	43.0	58.6	62.7	6	59.2	148.2	28.2
NI17410	41.5	78.4	72.7	62.7	48.6	70.8	60.2	46.6	58.6	62.5	7	59.8	146.1	28.1
LCS Valiant	42.2	72.8	66.6	59.0	54.0	73.9	68.0	38.6	60.5	62.5	8	59.2	145.7	26.1
NE14494	41.9	78.4	64.1	65.2	51.5	72.1	59.1	41.3	62.5	62.4	9	59.3	147.6	28.9
NW15443	45.7	76.6	64.9	64.6	52.4	71.8	53.8	44.5	56.9	61.5	10	57.3	149.3	29.2
NE14434	43.9	77.9	70.4	59.0	50.0	70.4	60.5	41.2	58.4	61.4	11	57.8	149.2	28.8
NW13570	43.7	78.2	73.1	62.2	47.7	74.8	60.8	40.7	48.2	61.2	12	58.0	148.6	27.7
NE15624	41.6	75.5	64.6	60.6	54.7	71.7	59.9	39.2	55.7	60.8	13	57.5	147.7	25.3
Robidoux	37.2	78.4	58.5	61.4	49.6	71.2	65.8	39.1	59.0	60.8	14	57.8	147.9	27.7
Ruth	40.8	80.0	61.7	58.7	48.6	70.2	57.5	38.8	64.7	60.6	15	58.9	148.4	28.2
NE15410	38.3	69.1	56.2	60.2	55.4	77.5	62.4	40.6	59.9	60.6	16	58.3	146.5	28.5
NE14696	43.4	71.7	62.3	57.7	52.2	67.3	59.7	42.0	57.8	59.8	17	56.0	148.0	28.4
Freeman	38.8	68.7	63.8	58.7	52.6	70.7	60.0	42.4	59.3	59.7	18	56.8	147.8	27.4
NE14691	44.3	75.6	68.0	63.6	49.1	64.5	58.0	41.7	50.8	59.6	19	57.2	148.5	28.2
NE16563V	38.4	72.9	65.4	59.1	53.2	67.4	58.1	44.2	53.6	59.4	20	57.1	148.7	26.0
Panhandle	38.0	73.6	59.2	60.8	48.2	69.6	55.7	45.2	57.8	58.8	21	57.8	148.2	31.8
GOODSTREAK	47.2	66.6	65.4	58.3	51.8	61.3	57.9	40.8	55.1	58.3	22	58.2	148.0	32.5
Siege	39.5	69.5	63.1	60.0	46.9	69.2	58.2	40.3	53.7	58.0	23	59.1	146.6	26.8
SCOUT66	37.4	48.4	45.0	50.6	41.5	56.9	55.2	38.8	52.5	49.1	24	58.1	148.2	32.5
CHEYENNE	35.3	42.3	45.2	46.7	43.7	60.0	53.1	38.9	46.0	47.5	25	57.5	150.3	34.0
Average	**41.6**	**72.9**	**64.3**	**60.7**	**51.0**	**70.3**	**59.8**	**42.7**	**57.7**	**60.4**		**58.1**	**147.8**	**28.4**

As can be seen from the excellent three-year yields of recently released lines (LCS Valiant, Ruth, and Robidoux) and our new released line (NW13493) continue to do well, but we have many experimental lines with excellent grain yields in the east, central, or west parts of Nebraska. Of particular note is NE16562 which is under increase. NI13706 has excellent yield and is actually a good anther extruder as would be needed in hybrid wheat, but its end-use quality is not good enough to warrant release. As expected, Cheyenne and Scout 66 were the lowest yielding lines. Both broadly and more narrowly adapted lines have value in wheat production, and we breed for both.

5. Nebraska Triplicate Nursery (NTN):

The same comments about the NIN data apply to the NTN. A number of experimental lines did very well and were superior to Ruth.

The data for 2020 are:

Name	Mead Yield bu/a	Linc. Yield bu/a	C.Center Yield bu/a	N.Platte Yield bu/a	McCook Yield bu/a	Grant Yield bu/a	Sidney Yield bu/a	Alliance Yield bu/a	Average Yield bu/a	Rank	Test Weight lbs/bu	Hdate days after 1-Jan	Height In
NE19590	63.0	61.5	68.8	58.7	61.9	36.7	38.6	38.0	53.40	1	58.1	151.7	29.3
NE19471	63.9	59.0	68.5	57.3	69.0	30.5	38.0	39.2	53.18	2	58.1	152.4	32.8
NHH19668	63.6	59.2	70.2	57.1	62.2	33.0	39.7	39.1	53.01	3	60.9	151.4	27.3
NE19618	59.3	64.2	65.4	53.6	65.1	42.0	37.8	36.6	53.00	4	57.7	151.4	32.3
Ruth	**60.5**	**64.9**	**68.2**	**52.1**	**60.0**	**35.4**	**41.5**	**40.3**	**52.86**	**5**	60.4	152.3	29.3
NE19542	58.5	64.0	65.4	54.2	64.5	38.4	38.4	35.4	52.35	6	58.0	153.7	28.5
NE19568	55.9	58.5	64.4	54.7	57.5	36.2	46.0	44.1	52.16	7	58.7	150.0	31.3
NHH19651	64.8	57.6	65.0	50.7	69.3	32.2	41.4	36.1	52.14	8	56.1	150.9	30.8
NE19418	54.7	61.1	65.0	53.8	62.6	40.1	39.4	39.9	52.08	9	59.2	149.4	29.5
NE19638	57.8	58.3	71.3	57.1	67.7	34.8	36.0	32.1	51.89	10	58.6	152.2	29.8
NE19430	50.7	55.1	70.0	55.5	64.0	32.2	44.3	39.9	51.46	11	53.5	152.9	29.8
NE19619	55.5	58.8	61.3	56.0	62.9	30.5	44.9	39.5	51.18	12	55.5	154.6	31.5
NE19472	51.2	60.3	64.4	47.4	56.6	35.2	53.6	38.9	50.95	13	58.2	152.0	30.0
NE19454	47.0	57.4	70.0	48.4	65.0	35.1	46.2	37.1	50.78	14	59.2	151.2	27.5
NE19611	51.6	54.4	65.2	57.5	65.7	34.9	42.1	34.4	50.73	15	58.8	151.3	28.5
NE19601	61.2	60.4	68.3	52.1	64.2	30.6	36.5	31.3	50.58	16	59.2	153.4	32.5
NE19576	57.8	56.3	70.4	54.2	54.9	31.4	36.4	42.3	50.46	17	53.7	152.3	30.0
NE19455	51.5	57.5	55.4	59.1	59.8	35.6	43.9	40.4	50.40	18	60.2	149.2	26.5
NE19583	57.0	59.7	68.8	53.0	59.3	33.8	36.9	33.7	50.28	19	57.4	152.7	31.0
NE19540	57.6	56.0	67.5	48.4	61.4	35.0	44.8	30.5	50.15	20	57.3	153.1	32.5
NE19520	59.5	59.2	61.2	47.8	66.9	31.9	36.5	38.2	50.15	20	57.5	152.1	30.0
NE19415	51.7	51.9	66.4	57.0	61.9	32.3	39.2	40.3	50.09	22	55.9	151.8	31.8
NE19499	56.7	55.2	59.8	51.8	61.0	44.6	43.3	27.9	50.04	23	57.6	150.7	28.0
NE19412	55.7	55.7	68.5	45.5	56.6	35.0	36.9	45.5	49.93	24	58.4	148.8	29.0
NE19586	44.0	58.9	72.1	49.8	59.6	36.9	36.6	40.4	49.79	25	55.7	152.8	28.5
NE19424	54.1	58.3	63.2	47.2	55.8	34.7	47.8	36.0	49.64	26	56.1	152.3	30.0
NE19406	59.0	57.4	56.4	48.0	58.8	36.7	46.0	33.8	49.51	27	56.4	151.1	29.8
NHH19666	46.0	58.4	66.3	56.4	65.2	35.0	29.6	36.0	49.11	28	59.3	151.1	26.3
NHH19654	50.3	59.9	65.8	52.7	53.4	31.2	39.5	40.0	49.10	29	58.0	152.1	30.0
NE19589	59.1	52.5	62.0	48.4	56.5	33.6	43.0	37.6	49.09	30	57.2	152.9	29.0
NE19487	54.6	62.9	63.8	47.3	63.1	23.9	45.6	29.9	48.89	31	55.4	150.9	30.0
NE19605	49.1	59.9	60.4	48.9	58.9	33.4	41.1	39.2	48.86	32	49.2	152.6	30.8
NE19431	55.7	55.2	66.2	54.3	58.2	28.9	31.1	40.9	48.81	33	58.9	150.8	31.5
NE19570	53.3	54.7	65.5	52.0	55.0	35.2	37.2	37.3	48.78	34	60.8	151.1	30.3
NE19572	51.8	54.0	63.2	44.6	59.9	35.4	38.0	43.2	48.76	35	54.7	151.7	32.3
NE19528	57.8	51.6	64.1	49.0	55.9	31.2	40.4	38.9	48.61	36	54.0	153.5	31.3
NE19501	46.3	51.6	68.9	55.6	56.4	27.8	47.8	34.2	48.58	37	60.0	152.8	29.3
NHH19658	49.9	51.2	66.8	45.9	58.7	34.7	32.3	48.7	48.53	38	56.7	152.2	32.5
NE19480	50.7	55.4	70.3	53.4	57.6	31.8	34.8	33.5	48.44	39	56.4	150.1	32.0
NHH19667	56.1	54.8	60.4	53.3	59.3	35.2	30.1	38.1	48.41	40	58.5	149.6	28.0
NE19562	50.5	56.8	66.4	51.5	59.7	35.6	34.2	32.6	48.41	41	59.2	153.2	30.5
NE19544	53.0	50.4	64.0	47.5	55.9	28.4	49.7	38.4	48.41	42	49.3	153.2	32.3
NE19488	46.7	54.9	68.5	52.9	51.6	29.3	36.1	44.2	48.03	43	57.3	152.2	30.0
GOODSTREAK	**57.2**	**53.6**	**68.1**	**42.8**	**55.8**	**29.4**	**38.0**	**36.6**	**47.69**	**44**	56.0	151.2	34.8
NE19498	47.3	57.1	60.6	44.8	62.2	32.8	41.0	35.6	47.68	45	60.4	152.6	30.3
NE19429	47.2	57.6	60.8	55.4	53.0	27.7	46.1	30.5	47.29	46	59.0	150.4	31.0
NE19482	49.1	55.3	64.5	50.0	56.7	31.7	36.4	33.0	47.09	47	54.1	152.5	31.5
NE19574	56.0	57.5	56.7	44.2	64.1	26.9	36.9	33.9	47.03	48	58.2	151.0	31.5
NE19462	55.1	50.7	60.1	42.9	53.6	38.2	38.0	36.2	46.85	49	55.5	152.0	29.0
NE19497	46.9	60.4	57.2	50.5	55.7	31.4	37.1	34.2	46.68	50	56.9	151.8	32.8
NE19404	49.5	57.8	58.1	49.5	55.7	31.8	38.6	31.7	46.59	51	57.7	151.5	29.0
NE19416	48.2	51.7	57.8	42.6	56.3	35.0	39.4	38.0	46.13	52	57.2	152.0	33.8
NE19605a	52.8	49.1	62.7	47.1	59.4	29.4	37.5	27.6	45.70	53	57.7	151.2	30.0
Freeman	**51.5**	**53.3**	**60.7**	**49.6**	**49.8**	**31.5**	**36.7**	**32.2**	**45.66**	**54**	56.4	151.8	28.3
NE19646	50.0	54.7	59.2	35.5	59.5	25.8	37.2	39.5	45.18	55	52.6	153.7	35.8
NE19451	42.8	54.7	64.7	42.5	51.5	29.3	38.0	37.8	45.16	56	57.7	151.9	30.8
NE19564	51.0	53.9	55.1	45.7	53.2	29.7	41.9	30.4	45.11	57	49.3	154.4	32.5
NE19440	45.5	58.0	57.1	44.9	49.2	29.3	35.0	40.5	44.94	58	55.3	152.6	31.0
NE19571	51.4	43.6	64.9	38.3	56.2	32.4	33.2	36.6	44.58	59	57.1	151.7	32.3
NE19421	46.2	49.3	57.2	46.4	43.8	30.3	36.0	37.6	43.35	60	56.7	149.5	28.3
Average	53.37	56.39	64.15	50.23	58.92	32.99	39.5	36.92	49.06		57.0	151.8	30.4
LSD	10.75	8.97	9.95	9.14	11.16	10.27	13.54	7.98	10.22				
CV	10.41	8.22	8.05	7.47	7.79	12.81	17.71	13.36	10.73				

The data for 2019 are:

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

The data for 2018 are:

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

6. **Regional Nurseries** (data courtesy of J. Boehm, Jr. and S. Masterson)

In 2020, we continued to combine the Southern Regional Performance Nursery (SRPN) and the Northern Regional Performance Nursery (NRPN) into one larger nursery. These were planted at Lincoln, North Platte, Sidney, and Alliance. At Clay Center, only the SRPN was planted. The NRPN and SRPN data from all locations is available at: http://www.ars.usda.gov/Research/docs.htm?docid=11932. It was useful to see Kharkof and Scout 66, older wheat cultivars, continue to be very low yielding, indicating that breeding has made ongoing and continued progress. NI1740 performed well across the region for the second year which is very rare as we are a northern (late) site for breeding. The last line with performance well across the region was Robidoux.

		SRPN Overall		Clay Center, NE		Lincoln, NE		North Platte, NE		Sidney, NE		Alliance, NE		Goehner, NE[8]	
Entry	Line	Mean	Rank	Mean	Rank	mean	rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
1	Kharkof	2477	50	2990	49	2674	50	1690	50	1912	45	1683	47	3670	48
2	Scout66	3060	47	3237	45	3100	47	2033	49	1704	48	2466	31	5357	47
3	TAM-107	3790	46	3880	34	2957	48	2681	43	2464	22	2244	41	7519	33
4	Jagalene	3996	38	4378	18	3571	30	3416	6	2139	34	2623	24	8897	5
5	K19U7124R10	2965	49	3190	46	3172	45	2569	46	1995	43	1471	48	3465	49
6	K19U7126R37	3005	48	2627	50	2885	49	2479	48	1639	50	1435	49	2766	50
7	KS15H137-2	4338	15	4598	9	3833	17	3551	3	2011	42	2735	21	8043	21
8	KS17H17	4275	18	4015	29	3593	29	2744	41	2329	26	2847	15	7349	35
9	KS17H91-1	3869	43	3329	44	3555	34	2652	44	2757	12	2246	40	6940	40
10	TX15M8024	3808	45	4268	20	3123	46	3277	12	2132	35	2029	44	5896	45
11	TX16A001183	4084	32	3833	38	3602	28	2946	33	2549	19	2558	26	6415	43
12	TX16A001193	4018	36	4203	21	3340	42	2993	29	2309	28	2993	9	7943	23
13	TX16A001205	4200	22	3629	42	3562	32	3217	13	2804	11	2508	30	6171	44
14	TX16A001289	4175	24	3842	37	3499	38	2912	36	2733	14	3011	8	7249	36
15	TX16A001405	4543	3	4609	8	3943	12	3320	9	2659	17	2730	22	9216	2
16	TX16M9216	4378	11	4739	6	3730	21	3192	15	2932	7	3033	7	8338	13
17	TX16M9315	4377	12	3818	40	3744	20	3179	17	3215	5	2529	29	8238	16
18	ON1366277	3911	40	4396	17	3430	40	2634	45	2477	20	2811	16	8442	10
19	ON13P016	4132	26	3972	30	3320	43	2863	38	3235	4	2739	20	8368	12
20	19CP010066	4126	29	3031	48	3560	33	3109	22	2069	36	2152	42	9276	1
21	19CP010063	4447	6	4611	7	4367	2	3517	5	2044	38	3138	4	8892	6
22	19CP010068	4567	2	4750	5	4113	7	3046	25	2242	31	3138	5	9096	3
23	19CP010057	4413	10	4185	24	4203	4	3206	14	2851	10	2116	43	8208	17
24	BASF 1	4080	33	4203	22	3842	16	2923	35	2325	27	2450	32	8422	11
25	BASF 2	4194	23	4111	27	3681	23	2800	40	2396	23	2898	12	7963	22
26	LCH17-3481	4064	34	4468	13	3726	22	3042	26	2863	9	3416	2	7479	34
27	LCH17-5221	4272	19	3957	31	4152	6	3071	24	2872	8	3338	3	8073	20
28	LCH17-5660	4227	20	3936	33	3636	26	3351	7	2165	33	2553	27	7564	32
29	LCH17-4196	4432	7	4822	4	3508	36	3741	1	2556	18	2943	10	7918	24
30	LCH18-7071	4613	1	4929	2	4441	1	3284	11	2706	15	2585	25	7669	30
31	CO15D098R	4498	4	4952	1	4167	5	3174	18	2363	25	3046	6	8702	8
32	CO14A136-135	4280	17	4183	25	3806	18	2874	37	2228	32	2345	38	8677	9
33	CO14A055-258	4420	9	4468	14	4248	3	3726	2	3470	3	2881	13	7883	25
34	CO16SF065	4126	28	3046	47	3486	39	3141	21	3488	2	2858	14	7838	27
35	CO16SF070	4431	8	4194	23	3912	14	3304	10	4118	1	2428	33	8103	19
36	KS12DH0090-172	3818	44	3849	36	3658	25	2932	34	1852	46	1394	50	7174	39
37	KS12DH0156-88	4056	35	4131	26	4044	9	2860	39	1762	47	2018	45	6845	41
38	KS13DH0041-35	4484	5	4421	16	4055	8	3190	16	2746	13	2793	17	7244	37
39	KS13DH0030-28	4203	21	4459	15	3966	11	3150	20	3008	6	2360	35	5876	46
40	OK16729W	4345	14	4597	10	3663	24	3537	4	2022	39	2786	19	8263	15
41	OK16D101089	3910	41	4042	28	3988	10	3102	23	2018	40	2356	36	7634	31
42	OK168512	4282	16	3865	35	3627	27	2737	42	2280	29	3450	1	7778	29
43	OK188608	3904	42	3806	41	3253	44	2497	47	2011	41	2919	11	6610	42
44	OK15MASBx7 ARS 8-1	4135	25	3616	43	3506	37	2963	30	2069	37	1814	46	8163	18
45	OK16D101105	3968	39	3950	32	3553	35	2952	32	1935	44	2369	34	7189	38
46	NE16562	4014	37	3820	39	3918	13	3040	27	2273	30	2641	23	7858	26
47	NI17410	4366	13	4533	12	3428	41	3015	28	2473	21	2793	18	8847	7
48	NE17433	4098	31	4577	11	3869	15	2963	31	2381	24	2343	39	7823	28
49	NHH17450	4129	27	4300	19	3564	31	3174	19	2690	16	2352	37	9022	4
50	NHH17612	4114	30	4903	3	3786	19	3347	8	1683	49	2531	28	8268	14
	Mean	4090		4082		3667		3022		2439		2558		7533	
	l.s.d. (alpha = 0.05)	134		826		712		415		1017		737		1411	
	CV	10.3		12.4		12.0		8.5		25.7		17.8		9.3	

The data for the 2019 SRPN are:

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

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

		Overall NRPN		Lincoln, NE		North Platte, NE		Sidney, NE		Alliance, NE		Goehner, NE[1]	
Entry	Line	mean	rank	mean	rank	mean	rank	mean	rank	mean	rank	mean	rank
1	Kharkof	3218	41	2674	41	1690	41	1912	37	1683	41	4214	41
2	Overland	4658	15	4066	13	2950	30	2226	28	2224	32	8128	5
3	Wesley	4295	39	3883	20	3116	18	2298	24	2201	34	7549	16
4	Jagalene	4376	34	3571	36	3416	3	2139	32	2623	10	7938	11
5	Jerry	4406	32	3315	39	3073	23	2432	18	2786	5	7319	21
6	17NORD-94	4473	27	4098	10	3004	28	1944	35	2042	37	6970	25
7	18NORD-103	4452	29	4013	14	3006	27	1986	33	1930	40	6940	26
8	18NORD-104	4301	38	3961	18	2914	32	2246	27	1955	39	6281	35
9	18NORD-111	4591	19	3784	24	3129	16	2690	11	2538	20	6500	32
10	18NORD-108	4389	33	3681	32	3215	12	2208	29	2287	29	6171	36
11	19CP010075	4649	16	3679	33	2939	31	2627	14	2585	16	8388	3
12	19CP010078	4894	3	4158	7	3295	8	2905	6	2502	22	8667	2
13	19CP010081	4507	23	3306	40	2903	33	3105	3	3120	2	5851	40
14	19CP010083	4361	35	4324	5	2636	38	2585	17	2746	8	8028	8
15	19CP010076	4788	8	3558	38	3188	15	3008	5	2576	17	6610	31
16	LCH17-5660	4717	12	3636	34	3351	5	2165	31	2553	18	7409	19
17	DH15HRW-63-81	4407	31	3824	22	3028	25	2199	30	2585	15	6780	30
18	LCH18-7115	4618	18	4109	9	3542	1	2302	23	2219	33	7179	23
19	LCH17-1296	4525	21	3681	31	3028	26	2634	13	2237	31	7798	14
20	LCH17-3468	4483	25	3979	16	3215	13	1879	38	2024	38	8028	9
21	NE15624	4680	13	4358	4	3080	22	2293	25	2468	24	7898	12
22	NW15443	4882	4	4369	3	3472	2	2425	19	2320	28	9057	1
23	NE16562	4507	22	3918	19	3040	24	2273	26	2641	9	6900	27
24	NHH17612	4482	26	3786	23	3347	6	1683	41	2531	21	7379	20
25	NE17441	4642	17	3723	29	2816	35	1986	34	2486	23	8118	6
26	NE17443	4469	28	3762	27	2629	39	2313	21	2421	26	6990	24
27	NE17544	4579	20	4087	12	2784	37	2603	16	2103	36	8028	10
28	NE17590	4306	36	3779	25	2488	40	1874	39	2457	25	6400	33
29	MT1745	4784	9	3629	35	3190	14	3401	1	2612	13	7609	15
30	MT1746	4248	40	3721	30	2829	34	2419	20	2278	30	6041	38
31	MTCL1737	4503	24	3571	37	3085	21	2809	9	2621	11	6400	34
32	SD12DHA00031	4802	7	3986	15	3246	11	3219	2	2549	19	7219	22
33	SD12DHA01373	4904	2	4089	11	2981	29	3076	4	2780	6	7539	17
34	SD12DHA01688	4718	11	4122	8	3275	10	2717	10	2946	3	7479	18
35	SD12DHA03282	4863	6	3775	26	3282	9	2856	8	3342	1	6830	29
36	SD12DHA03429	4424	30	4167	6	2791	36	2307	22	2421	27	6860	28
37	SD13DHA02346	4667	14	3840	21	3405	4	2894	7	2605	14	6031	39
38	SD14355-2	4302	37	3757	28	3120	17	1686	40	2188	35	6131	37
39	SD15004-2	4926	1	4421	1	3094	20	2607	15	2614	12	8088	7
40	SD15035-2	4871	5	4400	2	3347	7	2668	12	2748	7	8158	4
41	SD15205-1	4753	10	3972	17	3100	19	1944	36	2928	4	7888	13
	Mean	4546		3867		3050		2428		2475		7214	
	l.s.d. (alpha = 0.05)	259		759		468		1099		857			
	CV	14.9		12.1		9.4		27.9		21.3			

The data for the 2019 NRPN are:

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

7. Multiple-Location Observation Nursery

Eight locations in Nebraska (Lincoln, Mead, Clay Center, North Platte, McCook, Grant, Sidney, and Alliance) and one in Kansas were planted and harvested. To better estimate the yield at key locations, two replications were planted at Lincoln. The table below gives the grain yields for all of the harvested locations, the line average, and the rank of the top 15 highest yielding lines. Note Sidney was severely infested with wheat stem sawfly and had some drought which did not allow us to use the data to separate the lines. Alliance also had drought and we could not separate the lines there also. So the average was based on the locations that we were able to separate lines. In this nursery, we continued to use marker-assisted selection for line advancement. Currently our dense genetic maps allow us to predict the presence of more than 50 traits (growth and development genes, major disease and insect resistance genes, and end-use quality genes). For the sixth year, we used genotyping by sequencing (GBS). The top fifteen lines out of 270 experimental lines are below. As can be seen some of the selected lines had low genetic estimated breeding values (GEBVs) because they seem to do particularly well in some section of the state and the GEBVs are based upon the state-wide averages. Historically, the lines that eventually become varieties are those that do well phenotypically (e.g. high grain yield) and also have higher GEBVs (priority group 1). We believe the excellent phenotypic values in a given year prove the line can do well in one year and the excellent GEBVs document that it can do well on average for the other years (the basis for obtaining the estimated breeding values is multiyear trials). Some lines with less than desirable stem rust values (SR, e.g. > 2+) are kept because the stem rust tests are seedling tests and some lines may have adult plant resistance.

Name	Traits	Mead	Lincoln	C.Center	N.Platte	McCook	Grant	Sidney	KANSAS	**Average**	**Rank**	**GEBV_yldbua**	**PriorityGroup**	Stem Rust
		Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	**No S, No A**	**No S, No A**			Rating
		Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	Bu/a	bu/a				
NE20620		57.36	70.37	66.69	54.33	82.34	49.98	31.18	58.36	63.51	1	NA	**NA**	;|;
NHH20655	IMI	53.30	68.15	70.55	53.80	78.98	54.50	33.78	59.78	63.21	2	0.23	**4**	2-|2-
NHH20669	IMI	68.13	66.74	60.33	57.30	77.85	45.94	31.98	55.60	62.71	3	1.29	**1**	2--|2--
NHH20668	IMI	55.40	66.95	64.21	53.57	81.13	53.91	32.75	58.28	62.53	4	2.10	**1**	;|;
NE20558	WSM2	62.17	73.85	60.61	51.47	79.89	45.33	31.99	53.10	62.22	5	1.64	**1**	;|;
NHH20667	IMI	61.44	67.43	65.07	55.65	79.27	41.96	32.14	61.85	61.80	6	0.32	**2.2**	;3-|;3-
NE20428		60.05	60.97	60.75	51.91	86.39	50.28	31.74	61.51	61.72	7	-0.64	**4**	;|;
NE20491		62.09	70.15	58.15	51.83	83.73	43.00	28.55	68.63	61.49	8	-1.40	**4**	2-|2-
NE20572		48.91	67.16	62.42	56.68	83.89	47.72	29.06	60.85	61.13	9	-0.03	**4**	;1-|;1-
NHH20660	IMI	54.86	64.40	60.59	51.27	83.34	51.95	30.07	61.27	61.07	10	0.46	**2.2**	;3-|;3-
NE20641		60.34	67.27	62.92	50.46	79.37	44.90	28.61	45.70	60.88	11	0.23	**4**	;N|;N
NHH20659	IMI	53.95	67.63	65.42	52.06	77.38	45.94	32.56	71.55	60.40	12	-0.70	**4**	3-|3-
NHH20662	IMI	54.79	65.13	63.06	53.52	72.64	52.82	31.84	64.83	60.33	13	0.53	**2.2**	;3-|;3-
NHH20664	IMI	59.71	61.58	57.99	55.03	82.84	44.47	30.11	68.36	60.27	14	1.57	**1**	1|1
NE20554		60.17	62.59	64.34	53.56	72.25	48.16	29.83	52.61	60.18	15	0.77	**2.2**	;1-|;1-

The top 15 lines for 2019 were.

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

Of the top 15 lines (5.5% of the total number of lines), seven are in the NIN21 or IRDR21 (~ 50% of the selected lines)

The top 15 lines for 2018 are:

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

Of the top 15 lines (5.5% of the total number of lines), three (20%) are still being testing in the NIN.

8. Early Generation Nurseries

A summary of the early generation nurseries is:

2020	Planted 19	Planted 20
WF2	1156	740
Imi-WF2	119	113
CoAxium -WF2	10	16
WF2 from Hybrid Yield trials	61	70
WF3	1056	1191
Imi-WF3	69	113
Headrows	41440	4200
Imi-Headrows	3840	3600
Preliminary Observation Plot	1597	1782
Imi Preliminary Obs. Plots	257	148

These numbers are fairly normal for the nurseries. For the WF2s, the better looking populations were sampled twice, hence the numbers that were advanced can occasionally be larger than the number previously planted.

9. Winter Triticale Nursery

Triticale continues to be an excellent alternative small grains cereal for the Great Plains, nationally, and internationally. Triticale cultivars released from our program are grown from New Mexico to New York. The main market is for annual forage crops, but there is also an emerging grain crop. One triticale cultivar is registered and released in Turkey. In the new cultivar section, we have discussed NT13443 (a good grain and forage triticale) and listed those lines under increase for possible release in the near future. The data for 2020 are:

	Mead	Linc.	Sidney	Avearge		Flowering	Height	Forage Data Mead		
	Lbs/a	Lbs/a	Lbs/a	Lbs/a		date	in	Dry Matter	Dry Forage	
NewName					**Rank**	D after 1/1		%	lbs/a	**Rank**
NT19406	3835	4094	1757	3228.7	**1**	153.2	41.6	0.22	2808.2	**4**
NT19418	3531	3599	2117	3082.3	**2**	152.2	39.5	0.23	2137.5	**20**
NT19416	3107	3567	2038	2904.0	**3**	152.3	38.8	0.23	1975.7	**25**
NT19443	3223	4195	1254	2890.7	**4**	153.5	43.9	0.21	3255.3	**1**
NT19433	3191	3248	2122	2853.7	**5**	151.2	40.3	0.27	1883	**28**
NT19426	3146	3472	1906	2841.3	**6**	153.3	40.0	0.22	2106.7	**21**
NT12403	3338	3561	1504	2801.0	**7**	151.2	42.1	0.23	2055.8	**22**
NT18430	3119	3883	1393	2798.3	**8**	153.3	47.4	0.23	2269.2	**14**
NT12404-1	2978	3512	1789	2759.7	**9**	151.2	40.7	0.24	2151.7	**19**
NT19428	3390	3490	1323	2734.3	**10**	150.7	40.8	0.26	2466.8	**11**
NT14407	3168	3373	1590	2710.3	**11**	150.8	43.4	0.25	2370.1	**12**
NT18410	2977	3234	1710	2640.3	**12**	152.2	40.4	0.24	2193.1	**15**
NE03T416-1	2986	3274	1635	2631.7	**13**	153.7	40.5	0.23	1845.6	**29**
NT19409	3006	3243	1564	2604.3	**14**	153.5	41.5	0.21	2276.8	**13**
NT17442	2815	3449	1469	2577.7	**15**	153.7	47.9	0.23	2642.6	**7**
NT17441	3079	3485	1128	2564.0	**16**	153.3	48.5	0.24	2859.1	**3**
NT19429	2832	3343	1400	2525.0	**17**	151.3	40.7	0.27	2018.2	**24**
NT19441	2993	2938	1613	2514.7	**18**	153.0	50.8	0.23	3159.4	**2**
NE03T416-3	2849	3239	1304	2464.0	**19**	153.3	39.4	0.22	2170.2	**16**
NT19410	2706	3349	1322	2459.0	**20**	153.2	42.3	0.21	2563.2	**8**
NT19423	2992	2969	1410	2457.0	**21**	152.3	41.8	0.22	2031.2	**23**
NT19442	2551	3078	1669	2432.7	**22**	154.0	42.4	0.2	2166.5	**17**
NT19413	2487	3169	1518	2391.3	**23**	153.8	42.9	0.2	2498.1	**10**
OVERLAND	2428	3285	1438	2383.7	**24**	154.4	31.4	0.21	1632.1	**30**
NT07403	2759	3190	1191	2380.0	**25**	150.0	38.1	0.27	2157.8	**18**
NT19434	2849	2714	1205	2256.0	**26**	153.0	49.7	0.25	2666.8	**6**
NT441	2279	3000	1404	2227.7	**27**	154.2	48.2	0.22	2695	**5**
NT14433	2624	2750	1146	2173.3	**28**	153.5	49.6	0.22	2562.8	**9**
NT15406	2422	2955	1109	2162.0	**29**	150.8	38.0	0.26	1897.5	**27**
NT16402	2861	2290	880	2010.3	**30**	150.8	39.0	0.26	1926	**26**
GRAND MEAN	2950.72	3298.29	1496.86					0.23	2314.72	
LSD	453.5	337.1	576.6					0.03	697.96	
CV	9.33	6.2	23.34					7.72	21.45	

Note the grain yield is reported as lbs/a because a triticale bushel is 48 lbs (just like barley). The names highlighted in yellow have been released. Using lbs/a allows direct comparisons to wheat. Overland is a representative wheat variety. As can be seen, Overland yielded 2428 lbs/a 40.5 bu/a) at Mead, 3285 lbs/a (54.8 bu/a) at Lincoln and 1438 lbs/a 24.0 bu/a) at Sidney and was relatively low yielding compared to triticale. Triticale is taller than wheat and may shade or otherwise compete aggressively against a semidwarf wheat. By comparison the best grain triticale NT12404-1 being considered for release had an average grain yield of 2759.7 lbs/a averaged 16% greater grain yield than Overland.

The data for 2019 are:

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

The mean performance of Overland at Lincoln (with no fungicide spray) was 66.6 bu/a and at Sidney was 57.4 bu/a. By comparison the best triticale NE03T416-3 had a grain yield of 3802 lbs/a at Lincoln and 5966 lbs/a at Sidney and averaged 39% greater grain yield than Overland.

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

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

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

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

The western forage trial was lost in 2019 and 2020.

The three-year (2018-2020) grain and forage yield data summary for locations where we were able to harvest trials is presented below. Again, the lines highlighted in yellow have been released. The line which may have the greatest potential for the next grain release is NT12404-1forage release is NT14433. NT17441 may be an excellent dual purpose triticale for grain and forage.

	Mead	Linc.	Sidney			Jan.1)				
	Grain	Grain	Grain	**State**	**Grain**	**State**	**State**	Forage	Forage	Forage
	Yield	Yield	Yield	**Avg Yield**	**Yield**	**Avg. Hdate**	**Avg. Height**	dry matter	Yield dry	RANK
	(lbs/a)	(lbs/a)	(lbs/a)	**lbs/a**	**Rank**	**(d after**	**(in)**	%	lbs/a	
NT12404-1	3593	4033	3271	3844.4	1	146.9	43.6	0.26	2579.4	6
NT12403	3874	3845	3101	3780.3	2	146.6	44.6	0.25	2496.9	8
NT14407	3539	3879	3334	3778.8	3	146.6	46.6	0.26	2667.1	5
NT17441	3887	3520	3068	3650.5	4	150.1	51.8	0.235	2828.6	2
NT17442	3506	3783	2849	3580.2	5	150.2	50.7	0.225	2791.3	3
NT15406	3104	3906	2619	3500.2	6	146.2	42.9	0.28	2422.3	10
NT07403	3517	3665	2605	3476.2	7	145.4	41.6	0.28	2566.4	7
NT16402	3277	3548	2441	3344.9	8	146.0	42.7	0.27	2474.0	9
NT14433	2947	3517	2398	3177.8	9	148.6	52.7	0.245	2936.9	1
OVERLAND	2974	3159	2736	3085.4	10	149.3	35.4	0.23	2078.6	11
NT441	2932	2583	2877	2856.4	11	150.9	52.2	0.22	2783.0	4

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

10. Collaborative Research on Wheat Diseases

Dr. Stephen Wegulo, Department of Plant Pathology, and his staff continue to inoculate our experimental lines with wheat stem and leaf rust, and Fusarium head blight (FHB, research funded by the U.S. Wheat and Barley Scab Initiative). We are expanding into testing for FHB resistance in barley. We continue to improve the greenhouse tests for stem rust. With the advent of the new race of stem rust, Ug99 (which can overcome virtually all of the previously very durable resistance genes in wheat which were the main genes used in our program), we have greatly increased our efforts to introgress and pyramid new genes with our existing genes through the use of molecular markers. As the new race is in Africa and now west Asia, we have continued our testing in Kenya as part of a USDA-ARS sponsored program and greatly expanded a program in Egypt which is capable of screening lines for both stem and stripe rust resistance. Remarkably, despite the very mild winter in Egypt, our wheat, barely, and triticale lines vernalize and head there. The winter in Egypt also highlights which lines require less vernalization.

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

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

The best way to avoid the effects of scab (syn. Fusarium head blight, FHB) is by breeding resistant lines that in severe disease years respond well to fungicide treatments. Overland still has the best native resistance, but our newly released LCS Valiant has good FHB tolerance, as does the licensed line, NW13493. In previous research, we found *Fhb1*, a major gene for FHB tolerance, was not pleiotropic or linked to genes that reduce grain yield. We are using high yielding *Fhb1* lines from segregating populations and Wesley *Fhb1 or* Overland *Fhb1* in our crossing block. For the first time, we are seeing lines in our multiple-location observation nursery that contain *Fhb1*, indicating our breeding strategy is beginning to work. The backcrossing approach is probably the best way to move needed genes into adapted line for further wheat improvement. Ms. Fang Wang has generated a number of advanced backcross lines using some of the best material in our program. For example, LCS Valiant which has good native resistance to FHB and excellent grain yield is one of the recurrent parent lines into which *Fhb1* is being backcrossed. She continues to work on using genomic selection for enhance FHB tolerance. In collaboration with SDSU and Ohio State University, Ms. Wang is using genomic selection to identify lines without major genes that also have good FHB tolerance. We wish to thank the **U.S. Wheat and Barley Scab Initiative** for the continued funding to evaluate our lines for scab tolerance.

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

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

13. Hybrid Wheat: V. Belamkar, N. Garst, N. Miller, E. Karahan, P.S. Baenziger, A. Ibrahim (Texas A&M University), A. Adhikari (Texas A&M University), J. Rudd (Texas A&M University), and Bhoja Basnet (CIMMYT), J.-B. Sarazin, (Asur Plant Breeding in France, Jochen Reif (the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany), and Friedrich Longin (University of Hohenheim in Germany)

One of the great opportunities and challenges for wheat improvement is the development of hybrid wheat. Currently numerous companies have hybrid wheat breeding efforts with Asur Plant Breeding (formerly Saaten-Union Recherche) being one of a few companies that markets hybrid wheat. Our belief is that the public sector needs to have a public, transparent hybrid wheat breeding effort to advance the science and educate the next generation of plant breeders. We have been working on hybrid wheat for the past 7 years. As of January 2017, our efforts on developing a public, transparent hybrid wheat platform took a major step forward with the successful receipt of a NIFA-IWYP grant for hybrid wheat development. The University of Nebraska was the lead institution and will work closely with Texas A & M University, Kansas State University, Asur Plant Breeding in France, the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany led by Jochen Reif, and the University of Hohenheim in Germany led by Friedrich Longin. This grant is for 3-years (with a one year no cost extension) and will support additional testing of hybrids as well as fund research into some of the key questions regarding hybrid wheat production. In this research we have 4 main objectives.

2020 was a difficult year to do research as we had to work under covid-19 restrictions. We were fortunate that most of our crosses were made before our university greatly restricted our working in our campus greenhouses. Similarly, the summer was difficult in that we had to drive one person per vehicle to the field which greatly limited graduate students who did not have a driver’s license (nor was it easy to obtain a driver’s license as the licensing agencies were closed).

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

We continued to screen the Nebraska and Texas wheat breeding programs for anther extrusion (a male trait). In Nebraska we screened the preliminary yield trial (270 experimental lines grown in an augmented design), and the regional performance nurseries (~90 experimental lines from across the region) and a doubled haploid population (Freeman [excellent anther extrusion] x Camelot [very poor anther extrusion]) to further understand the genetics of anther extrusion. Dr. Nicholas Garst using the Hard Winter Wheat Association Mapping Panel (HWWAMP) found significant genotypic variation for anther extrusion, anthesis date, and plant height while pollination duration only had significant genotypic differences in seasons with mild temperatures. The best pollinators tended to be early and short statured (contrary to previous research that tall wheats were better pollinators). A GWAS using HWWAMP revealed a novel haplotype on chromosome 2A which separated the highest and lowest scoring lines for anther extrusion and would be a target for gene pyramiding. *PPD-D1a* had the largest effect on anthesis date accounting for 20% of the total variation while also being significantly associated with plant height. *Rht-B1* and *Rht-D1* were most important loci for plant height accounting for 17% of the total variation. No significant markers were identified for pollination duration. Hybrid breeders working to improve outcrossing should incorporate the novel haplotype for increased anther extrusion, pair parents based on photoperiod sensitivity and reduced height genes, and select environments with low heat stress for hybrid seed production. The best indicators of female receptivity appeared to be gape angle and 100% gape date (when all the spikes are fully gaping). Both female traits can be visually scored quickly and accurately. Other traits that were scored were duration of gaping, stigma exsertion, and gape closure. The female traits were highly correlated, so one or at most two could be used to select excellent female lines. Females in the hybrid crossing block in 2020 were screened for gape angle and 100% gape date. We will continue phenotyping for female traits in 2021 crossing block. This will further allow us to investigate the genetics of the female traits.

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

We continued to use Croisor® 100 to make hybrids. We continue analyzing the data, removing the spatial variation, comparing reciprocal crosses, and estimating heritability and heterosis from our 25 x 26 crossing block with the emphasis on determining the genetics of heterosis. We successfully used the balanced missing design pioneered by our German cooperators for the 2017, 2018 and repeated it in 2019 crossing blocks. In this crossing block, we had 50 males and 100 females (total of 150 lines with 25 males and 50 females selected by both UNL and TAMU) where each male was crossed to 14 females. To ensure that environmental hazards did not destroy the crossing block, we grew two crossing blocks (1 in NE and 1 in TX). Based upon the data from the hybrid yield trials grown in 2017-2018 and 2018-2019, we selected the best hybrids in NE and ecological regions in TX (Blacklands and Bushland). These selected hybrids were then grown in 2020 in a 3-replicate alpha lattice trial at 3 locations in NE, 2 locations in Blacklands, and 1 location in Bushland to confirm our previous data. The selected hybrids were largely different in each testing zone (NE, Blacklands, and Bushland) except for ~5 to 7 hybrids that yielded well in both states. As expected, using a replicated alpha lattice design was far more precise than our large augmented incomplete block designs with broad-sense heritability (H^2) increasing from ~0.3-0.4 to >0.75. We lost one location in Blacklands and the other location also had lower heritability due to an environmental catastrophe in 2020. Preliminary results indicate highest reproducibility of high yielding hybrids in Bushland, and varying results observed in NE. We will continue to test the performance of some of the selected hybrids in 2021 and 2022 (these are also being simultaneously being made in 2021 crossing block). In 2020, a hybrid was the highest yielding genotype at Alliance and North Platte, and was the second highest yielding genotype at Lincoln. In TX, one location was lost due to the bad weather, and a hybrid was the highest yielding genotype in one location and the second highest in another location. Detailed analyses to investigate reproducibility of heterosis are in progress.

In addition, we successfully negotiated a three-year supply of Croisor® 100 for future use and continued hybrid wheat research. To determine the effect of the Croisor® 100 on female seed set, we sprayed cytoplasmic male sterile (CMS) lines with Croisor® 100 and found the seed set on the Croisor® 100 sprayed CMS lines to be between 25 and 75% of the unsprayed CMS lines. The comparison is biased as we discovered some fertile males were contaminating the CMS lines (mechanical mixtures from the previous harvest hence the unsprayed CMS yield would be inflated). Also, Croisor® 100 delays gaping, so a Croisor® 100 sprayed CMS female will delayed and may have less chance to be pollinated. However, it does give an indication of the injury caused by Croisor® 100. This injury can be reduced with better adjuvants and application technology that is tailored to each female line as is done in commercial practice in Europe.

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

All of the parental lines have been genotyped, and the genomic and phenotypic analyses were completed to be point where we can predict using our hybrid yield data from 2018, 2019, and 2020 which hybrids should be made to obtain the highest levels of heterosis. The accuracy of predicting the yield of hybrids was higher in TX compared to NE locations. The high spatial-variation and low heritability values of large augmented trials in NE influenced the quality of phenotype, which resulted in lower prediction accuracy in NE compared to TX environments. This also indicates an opportunity for research and integrating digital phenotyping and additional field covariates to increase the accuracy of phenotyping large trials in NE. Further, the ~750 hybrids tested at three locations in NE and TX in 2018 and 2019 were used as training sets and hybrid yield of ~11,000 hybrids was predicted for NE and two mega-environments (Blacklands and Bushland) in TX. From these predictions, the top 1,000 predicted hybrids were selected initially using yield. Subsequently, we dropped ~750 hybrids based on whether a successful hybrid could be made using male and female key parental traits (anther extrusion and gape angle) and the nick scores (difference in the anthesis date of male and female line in a cross). Subsequently, we designed and planted a crossing block in NE and TX in 2019-2020 based on the predicted hybrids we want to test in 2021-22. The crossing block in NE comprised ~210 high-yielding crosses and ~40 low-yielding crosses predicted and selected as described previously and ~60 crosses for elite hybrids. In TX, the crossing block included ~130 high-yielding and ~20 low-yielding crosses each for Blacklands and Bushland environments (~300 crosses in total). Besides making the potential high-yielding hybrids that were previously not made, this crossing block in 2020 helped make hybrids to validate the genomic predictions. These hybrids made in 2020 are now being grown in 2-replicates, alpha lattice design, at three locations in NE, two locations in Blacklands, and one location (3 replicates) in Bushland. The 2020-2021 crossing blocks in NE and TX which will be sprayed and harvested in 2021 contains most of these crosses (to test hybrids for the second year), a small number of crosses grow in multiple plots to make elite hybrids for relatively larger scale testing, and in NE an additional 60-100 crosses based on high-GCA lines and heterotic groups identified using the annealing algorithm developed by our German Collaborators.

Objective 4: Map restorer genes in *T. timopheevi* cytoplasm and create a series of CMS tester lines, their maintainer lines, and a series of elite restorer lines (R-lines) and begin to determine the efficacy of CMS-based hybrid systems. The evaluation of a biparental mapping population for restorer (*Rf*) genes was completed. While some previously known *Rf* genes were found, additional novel *Rf* genes were mapped suggesting that this population based on one of the best restorer lines in Australia was a rich source of pyramided restorer genes. Work continues to develop through crossing and evaluation, modern winter and spring wheat restorer lines and male sterile lines using the *Triticum timopheevi* cytoplasm. As proposed in the grant, we have begun sharing our CMS A-lines and their B-line maintainer lines, as well as a few of the R-lines.

Based on the progress in the first grant, we successfully submitted a renewal and were awarded three more years of funding. Though not part of the above grant, Ms. Nichole Miller is using RNAseq to study how heterosis can be explained at the molecular level. Dr. Belamkar is using the wheat genome sequence to study restorer genes for the *T. timopheevi* cytoplasm which will complement well the information developed in objective 4 above. More information on these two projects is described in detail next.

14. Insights into the Heterosis Mechanisms of Wheat (*Triticum aestivum* L.) using RNA-Seq. N. Miller, S. Baenziger, V. Belamkar, S. Sattler, and J. Eudy.

In recent years, increasing consumer demand for wheat has put a strain on the ability of inbred commercial lines to match it. Hybrid wheat has been proposed as a tool to meet that growing demand but lacks research to allow breeders to take advantage of the heterosis (hybrid vigor) seen in other hybrid crops. The goal of this research is to conduct a comprehensive study involving 10 hybrids and their corresponding parents to identify transcriptome mechanisms that impact heterosis. The study comprises 10 chemical-hybridizing-agent (CHA)-made hybrids and their parents, called a triad, resulting in 30 unique genotypes. Of these 10 triads, 5 triads represent heterotic class and 5 non-heterotic, based on mid-parent heterosis values. Immature seed and flag leaves were sampled 7-10 days after flowering from each line and five biological replicates, and preserved for RNA extractions. Subsequently, three biological replicates per each tissue will be sequenced using 3’ RNA-Seq, resulting in ~180 samples. Transcript sequences will be trimmed for quality control and mapped to the reference genome. Separately, a study was also done on optimizing RNAlater, an RNA storage solution, to be used in wheat for potential use in sample collection and storage and it was concluded that it would be a viable option. Results from transcriptomic analysis may include determining hybrid purity, classification of gene expression into a gene action model, identifying differentially expressed genes within the triad, between triads, and between heterotic classes, and biological pathway enhancements that could explain improved performance. The results will identify heterosis mechanisms and can be used for hybrid wheat breeding efforts.

15. Comprehensive Characterization of Restorer-of-Fertility-like Gene Family in Bread Wheat Reveals Novel Alleles for Fertility Restoration. V. Belamkar, P. M. Terry, S. Blecha, J. Poland, B.R. Basnet and P.S. Baenziger

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

16. Integrating high throughput phenotyping (Phenomics) into breeding. M. Lien, Y. Ge, Y. Shi, V. Belamkar, I. El-Basyoni, R. Howard, D. Jardin, and P.S. Baenziger

One of the hottest fields in agricultural research is high throughput phenotyping. The importance of high throughput phenotyping increased when the massively successful high throughput genomics tools changed the resource allocation from understanding the genetics (which used to be very costly to now being relatively inexpensive) to tying back the genetics to the phenotype. Phenotyping became the costlier part of research. To put this in perspective a single plot in the state variety is valued at \$30-35, while the line in the plot can be completely genotyped for \$10 to \$20. Hence the main cost in a breeding program is now collecting excellent phenotypic data. Using unmanned aerial vehicles (drones), whole fields of breeding plots can be imaged in a few hours, meaning that objective data can be collected at the same time. For large fields, breeder phenotyping often took days and was subject to weather changes (rain, clouds, etc.) This research is part of the genome to phenome concept. Much of our previous research has been done to develop the phenotyping tools (image analysis from multispectral cameras for agronomically important traits). Now we are getting very close to fully integrating the collected images into breeding history and selections.

V. GREENHOUSE RESEARCH

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

VI. PROPRIETARY RESEARCH

Public Private (University of Nebraska) Collaborations:

In 2009, the University of Nebraska decided to sustain the wheat-breeding project via enhanced collaborations with commercial companies spanning the value chain. The University of Nebraska-Lincoln (UNL) has had a long-standing arrangement with BASF, providing access to the Clearfield technology. Infinity CL and Settler CL are outcomes of this research. Two new lines (NHH17450 and NHH17612) have been approved by BASF as having sufficient herbicide tolerance for release if their agronomic performance warrants release. Both lines are in regional nursery testing and being tested statewide in 2020. We have access to the CoAXium trait and breeding for tolerance to Aggressor® herbicide. We continue our collaboration with Ardent Mills who support our McCook Nursery and provide valuable information on the end-use quality of our lines at that site. Southwest Nebraska is a key sourcing site for their Colorado mills. In 2010, UNL developed a collaboration with Bayer Crop Science (now BASF) that allows non-exclusive access to UNL germplasm and is in accordance with the principles for collaboration approved by the National Association of Wheat Growers and with the U.S. Wheat Associates Joint Biotechnology Committee. This collaboration has led to extensive collaborations and interactions on genetics, plant breeding, and crop physiology. Having their excellent staff in Lincoln has been very advantageous to student and staff interactions. In 2018-20, we planted more than 750 doubled-haploid lines created in collaboration with Limagrain and are evaluating lines at Mead. So far one doubled haploid line LCS Link has been released and a second line has been licensed from this cooperative effort. In addition, it opened the door for marketing a winter triticale by Limagrain and LCS Bar was licensed to them, as was LCS Valiant which does well in western KS and in Nebraska. We hope that these collaborations will continue. KWS created a doubled haploid population so we can study anther extrusion from the cross Freeman (excellent anther extruder) x Camelot (a very poor anther extruder). This population was planted in the field for the first time in 2019 and will be evaluated by Mr. Emre Karahan, a new student on the project. Our cooperation on hybrid wheat is only possible due to a collaboration with Asur Plant Breeding in France and we are truly grateful that we are able to cooperate with them. Our agreements have been extended for the next three years. We have additional research agreements with other companies such as the new Bayer for sharing germplasm to testing lines to marketing lines nationally and internationally.

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

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

VII. Winter Barley Research

As previously mentioned, we expect to release NB15420 in 2021. NB15420 will be a non-exclusive release. Non-exclusive releases are preferred by the American Malting Barley Association and by the Brewers Association, both of which are funding the barley efforts on malting barley (specifically 2-row winter barley lines). To optimize our barley breeding efforts, we have developed a breeding and a testing collaboration with the USDA-ARS at Stillwater OK (began in the 2017-2018 season), Kansas State University at Hays KS, and with Drs. Dipak Santra, Cody Creech, and Amanda Easterly at Sidney NE. We currently our testing our advanced lines in OK, KS, and NE. The barley trial at Stillwater was hampered by covid-19 protocols which prevented timely harvest. The barley was severely lodged and the lines were not statistically different, hence the data is not reported here.

The data for 2020 from locations with good trials are:

Name	Linc. Yield lbs/a	Colby KS Yield Lbs/a	Average Yield Lbs/a	Rank	Colby KS Test Weight lbs/bu	Linc. Flowering Date (Julian)	Linc. Height in	Mead Winter Survival	Linc. Winter Survival
NB17411	3479	5926	4703	1	49.3	148.1	31.0	5.0	7.3
NB18429	3450	5764	4607	2	45.8	149.2	30.3	7.3	8.0
NB19420	3512	4953	4233	3	47.5	147.9	33.3	8.3	8.9
NB14404	3355	5101	4228	4	46.5	147.2	32.3	7.0	8.3
NB18406	3630	4789	4210	5	45.4	148.6	33.3	6.7	8.6
NB19434	3436	4950	4193	6	46.1	150.0	31.0	7.3	8.6
NB11416	3885	4498	4192	7	44.7	146.4	30.0	8.0	8.8
NB19422	3228	5142	4185	8	45.7	147.3	31.0	6.7	8.7
NB19406	3214	5140	4177	9	43.0	145.8	30.7	6.0	8.8
NB14422	3416	4798	4107	10	43.1	146.8	29.0	7.0	8.7
NB19423	2988	5208	4098	11	46.4	151.6	32.3	5.7	7.1
NB17431	3563	4602	4083	12	48.0	148.3	33.0	6.3	8.2
NB15415	3577	4585	4081	13	48.8	147.1	31.3	5.7	6.8
NB15442	3357	4676	4017	14	48.1	146.3	29.7	7.3	8.5
NB17409	3179	4815	3997	15	49.4	148.7	31.3	4.3	7.7
NB11414	2919	5028	3974	16	45.3	149.3	29.7	7.3	7.9
NB18411	3418	4499	3959	17	44.6	146.4	30.3	7.0	8.0
NB17401	3229	4641	3935	18	50.5	151.0	35.3	5.3	4.9
NB16412	3401	4410	3906	19	46.3	146.1	31.0	7.7	8.4
NB15420	3113	4653	3883	20	47.2	145.3	31.0	7.7	7.2
NB15417	3215	4280	3748	21	49.1	147.3	30.7	5.7	6.9
NB12437	3112	4336	3724	22	43.4	147.1	32.0	7.7	8.2
NB15441	2899	4471	3685	23	45.8	145.2	30.3	5.3	7.5
NB19433	2313	5027	3670	24	44.9	148.0	30.3	6.7	6.6
NB19443	2265	4949	3607	25	47.9	150.7	30.0	4.3	7.0
P-954	2158	5017	3588	26	46.7	149.5	28.0	7.0	5.3
P-845	2956	4164	3560	27	45.6	144.3	31.0	8.7	8.4
NB19417	1890	5167	3529	28	49.5	151.0	26.3	6.7	4.8
NB19418	2594	4419	3507	29	46.8	152.7	29.3	3.0	5.2
NB19403	3113	3897	3505	30	45.7	146.8	33.0	6.0	7.7
NB19442	2996	3947	3472	31	47.7	148.7	30.7	6.7	7.5
NB17415	2871	3994	3433	32	47.5	149.8	32.0	5.0	5.5
NB18417	2719	3948	3334	33	43.5	146.8	32.0	4.7	6.5
NB18416	3014	3610	3312	34	48.7	148.0	33.7	5.0	6.7
NB18408	2406	4188	3297	35	45.4	148.6	32.7	6.0	5.2
NB18439	1933	4208	3071	36	45.2	153.8	25.0	3.7	4.6
NB18422	1955	4181	3068	37	47.4	152.9	28.0	4.0	5.0
NB18435	2273	3376	2825	38	-	152.0	24.3	3.0	4.0
NB18401	1658	3713	2686	39	45.0	151.0	26.3	4.7	3.8
NB19408	1814	3288	2551	40	47.1	148.0	29.0	6.7	6.4
Average	2937.54	4558.92			46.49	148.48	30.54	6.1	7.06
LSD	590.9	838.45			1.51	2.23	2.69	2.07	1.62
CV	12.29	11.24			1.98	0.92	5.41	20.89	14.05

In 2019, Mead was lost to floods and Hays to a storm just before harvest which broke heads off and lodged the plants. The data for 2019 are:

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

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

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

The three year data for 2018-2020 are presented below:

	COLBY	Mead	Lincoln	Sidney	AVG	Rank	Flowering	Height	Test Wt	Winter
	Yield	Yield	Yield	Yield	Yield		Date			Survival
	lbs/a	lbs/a	lbs/a	lbs/a	lbs/a		d after 1/1	in	lbs/bu	9(best) - 1
NB17411	4294	2417	3773	4657	3854	1	141.3	29.6	44.9	6.2
NB17431	3572	3418	3753	4712	3790	2	141.6	32.5	44.5	7.3
NB17401	3547	3044	3644	4449	3646	3	142.8	33.9	46.7	5.1
NB14404	3575	2624	3788	4158	3614	4	139.1	29.3	42.9	7.7
NB15420	3374	3542	3540	4159	3581	5	138.1	29.2	44.9	7.5
NB15415	3285	2841	3875	3622	3523	6	139.4	29.1	46.9	6.3
NB12437	3619	2681	3383	4520	3513	7	141.1	29.7	42.3	8.0
NB17409	3679	2571	3339	4583	3504	8	142.8	30.7	44.8	6.0
NB11416	3373	2940	3754	3496	3492	9	139.3	26.9	42.2	8.4
NB11414	3662	2797	3267	4500	3489	10	141.3	28.8	42.9	7.6
NB14422	3390	2358	3819	3823	3488	11	140.1	27.0	41.2	7.9
NB15441	3315	3130	3397	4376	3475	12	138.6	28.9	44.4	6.4
NB16412	3313	2491	3660	4168	3466	13	139.6	29.6	43.8	8.1
NB17415	3195	3192	3356	4361	3430	14	141.1	30.8	45.0	5.3
NB15442	3312	2532	3516	3732	3348	15	138.9	28.4	44.9	7.9
P-954	3577	2297	3041	4565	3305	16	141.1	28.7	44.9	6.2
NB15417	3105	2849	3462	3657	3300	17	139.3	29.3	45.2	6.3
P-845	3013	2200	3484	3639	3188	18	136.7	29.3	42.0	8.6

The average is over each trial (N=7). What is interesting in this data is that the checks P-845 (formerly NB99845) and P-654 (formerly NB86954) were in the lower half of the trial indicating we had many superior lines. With additional testing and seed increases, we expect a number of them to be released. These data highlight that NB15420 is superior for grain yield over what is commercially available.

VIII. ALLIED RESEARCH

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

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

IX. COMINGS AND GOINGS

All projects are more than crosses, selections, evaluations, data, and seed. At its heart, it is the people who make this research possible. Drs. Ibrahim Salah El-Basyoni worked remotely for a year in Egypt before returning to UNL. He currently coordinates our Egyptian nurseries while on the faculty at his university. Dr. Odgerel Bold (from Mongolia) and Mr. Mujahid Alam (from Pakistan) joined the project as visiting scientists. Both have since returned home. Mr. Juan David Jimenez Pardo (M.S. student on hybrid wheat) and Ms. Sheryl Sierra (Ph.D. student on genomic selection/advanced breeding strategies) joined the project. Mr. Felipe Sperotto left the program to become a researcher with a private company that will allow him to return to Brazil in the future. 2021 will be a year of transition. Mr. Mitch Montgomery will retire after 24 years of excellent service. We are searching for his replacement now. Dr. P. Stephen Baenziger will retire in May 2021. We are very fortunate that his successor has been hired, Dr. Katherine Frels. The program will be in very good hands going forward. We are extremely grateful for the excellent work that the team has done and continues to do.

X. Publications from the Project:

1. Morgounov, A., Y. Karaduman, B. Akin, S. Aydogan, P. S. Baenziger, M. Bhatta, V. Chudinov, S. Dreisigacker, V. Govindan, S. Güler, C. Guzman, A. Nehe, R. Poudel, D. Rose,

E. Gordeeva, V. Shamanin, K. Subasi, Y. Zelenskiy and, E. K. Khlestkina. 2020. Yield and quality in purple-grained wheat isogenic lines. Agronomy 10: 86, (1-14).

2. Easterly, A. C., N. Garst, V. Belamkar, A. M. H. Ibrahim, J. C. Rudd, J.-B. Sarazin, and P. S. Baenziger. 2020. Evaluation of Hybrid Wheat (*Triticum aestivum* L.) Yield in Nebraska. Crop Science 60:1-13 . https://doi.org/10.1002/csc2.20019.

3. Easterly, A. C., W. Stroup, N. Garst, V. Belamkar, J.-B. Sarazin, T. Moittie, A. M. H. Ibrahim, J. C. Rudd, E. Souza, and P. S. Baenziger. 2019. Determining the efficacy of a hybridizing agent in wheat (*Triticum aestivum* L) .Scientific Reports 9:1-11.

4. Adhikari, A., A. M. H. Ibrahim, J. C. Rudd, P. S. Baenziger, and J.-B. Sarazin. 2020. Estimation of Heterosis and Combining Abilities of U.S. Winter Wheat Germplasm for Hybrid Development in Texas. Crop Science 60:788-803.

5. Elbasyoni, I.S., S. M. Morsy, M. Naser, H. Ali, K. P. Smith, and P.S. Baenziger. 2020. Reverse introduction of two-and six-rowed barley lines from the United States into Egypt. Crop Sci. 60:812-829.

6. Mourad, A. M. I., V. Belamkar, and P. S. Baenziger. 2020. Molecular genetic analysis of spring wheat core collection using genteic diverstiy, population structure, and linkage disequilibrium. BMC Genomics 21:434. https://doi.org/10.1186/s12864-020-06835-0

7. Adhikari, A., A.M.H. Ibrahim, J.C. Rudd, P.S. Baenziger, A. Easterly, N. Garst, V. Belamkar, J.-B. Sarazin. 2020. Supplementing selection decisions in a hybrid wheat breeding program by using F_2 yield as a proxy of F_1 performance. Euphytica 216: 130. [https://doi.org/10.1007/s10681-020-02664-0].

8. Baenziger, P.S., R.A. Graybosch, D.J. Rose, L. Xu, M.J. Guttieri, T. Regassa, R. N. Klein, G. R. Kruger, D. K. Santra, G. W. Hergert, S. M. Wegulo, Y. Jin, J. Kolmer, G. L. Hein, J.Bradshaw, M.-S. Chen, G. Bai, R. L. Bowden, I. El-Basyoni, and A. Lorenz. 2020. Registration of ‘NE10589’ (Husker Genetics Brand Ruth) hard red winter wheat. J. Plant Regist. 14(3): 388–397. doi: 10.1002/plr2.20068.

9. Bolanos-Carriel, C., S.N. Wegulo, P.S. Baenziger, D. Funnell-Harris, H.E. Hallen-Adams, and K. M. Eskridge. 2020. Effects of fungicide chemical class, fungicide application timing, and environment on Fusarium head blight in winter wheat. Eur. J. Plant Pathol. 158(3): 667–679. doi: 10.1007/s10658-020-02109-3.

10. Bolanos-Carriel, C., S.N. Wegulo, P.S. Baenziger, K.M. Eskridge, D. Funnell-Harris, N. McMaster, D. G. Schmale, and H. E. Hallen-Adams. 2020. Tri5 gene expression analysis during postharvest storage of wheat grain from field plots treated with a triazole and a strobilurin fungicide. Can. J. Plant Pathol. 42: 547-559. doi: 10.1080/07060661.2019.1700169.

11. Navrotskyi, S., V. Belamkar, P.S. Baenziger, and D. J. Rose. 2020. Insights into the gnetic architecture of bran friability and water retnetion carpacity , two important traits for whole grain end-use qulaity in winter wheat. Genes 2020, 11, 838; doi:10.3390/genes11080838

12. Munoz-Amatriain, M., J. Hernandez, D. Herb, P. S. Baenziger, A. M. Bechard, F. Capettine, A. Casas, A. Cuesta-Marcos, C. Einfeldt, S. Fisk, A. Gentry, L. Helgerson, M. Herz, G. Hu, E. Igartua, I. Karsai, T. Nakamura, K. Sato, K. Smith, E. Stockinger, W. Thomas, and P. Hayes. 2020. Perspectives in low termperature toelrance and vernalization sensititivity in barley: prospects for facultative grwoth habit. Front. Plant Sci. 11: 585927. doi: 10.3389/fpls.2020.585927.

13. Dawood, M. F. A., Y.S.. Moursi, A. Maro, P.S. Baenziger, and A. Sallam. 2020. Investigation of heat-induced changes in the grain yeild and grain metabolites, with molecular insights on the candidate genes in barley. Agronomy 2020, 10, 1730. doi:10.3390/agronomy10111730

14. Ayalew, H., M. Sorrells, B. F. Carver, P. S. Baenziger, and X.-F. Ma. 2020. Selection signatures across seven decades of hard witner wheat breeding in the Great Plains of the United States. Plant Genome. 2020;e20032. 1 of 10 https://doi.org/10.1002/tpg2.20032

Summary:

In 2019-2020 season, 900,000 acres of wheat were planted in Nebraska (a record low) and 830,000 acres were harvested with an average yield of 41 bu/a for a total production of 34,030,000 bu. The downward trend continued with 810,000 acres planted due to drought in fall 2020. In general, disease pressure was fairly low and mainly leaf rust with some pockets of Fusarium head blight. Wheat stem sawfly was prevalent in western Nebraska.

The project is formally releasing NW13493 which has been licensed to a major milling company (initially for organic production). NW13493 is an excellent white wheat with a good disease resistance package and good sprouting tolerance. It has excellent end-use quality. It performs well in every part of the state. Because it is a white kernelled wheat, we decided it needed to be licensed to ensure there would be a market for it. In addition, a new irrigated wheat NE15420 is being released. NE15420 does extremely well under irrigation, but is not recommended for rainfed production except under maximum management strategies. It has excellent straw strength and is short statured which is preferred by irrigated wheat producers. It has acceptable end-use quality. There is sufficient seed of both lines that growers should be able to purchase seed of each line in the fall of 2021.

Three new wheat lines are under increase for possible release in 2021. NHH17450 and NHH17612 have been approved by BASF to enter the Clearfield plus program is the agronomic data warrant release. NHH17450 has a good disease package, but is susceptible to leaf rust. NHH17612 has a similar disease package with moderate susceptibility to leaf rust. The third line is NE 16562 which is a high yielded hard red winter wheat that has good disease resistance overall, but is susceptible to stripe rust. All three lines are hard wheats with acceptable or better end-use quality. Our work on hybrid wheat continues and the hybrids continue to show better heat and drought stress tolerance than traditional cultivars. Our federal grant to continue developed hybrid wheat was funded for an additional three years. Meshing what we learn from hybrid wheat development into variety develop will play a key role in our future breeding effort. We are developing COAxium lines, wheat sawfly resistant lines, and lines with improved wheat streak mosaic and Fusarium headblight resistances. On the technology side, we are integrating genomic selection and high through put phenotyping to harness their extraordinary capabilities.

One new triticale, NT13443 will be released in 2021 and will be available to growers. It is an excellent forage triticale that has higher grain yields. Coupling high forage and grain yield has been very difficult in forage triticales which makes them hard for seed growers to produce. As second forage triticale, NT14433 is under increase to further diversify the market for forage triticales. A new grain triticale, NT12404-1 is under increase for possible release for those growers who want a feed grain triticale. In 2020, we identified a triticale head row with the finest seed quality that we have seen in triticale (very similar to rye, long slender grain without shriveling) and continue to develop awnless triticale varieties for forage production. However, awnless triticales do not seem to set seed as well as awned types, so we will monitor this trait. The triticale market continues to expand and out lines are being grown from New Mexico to New York.

In winter barley, NB15420 has been recommended for release. It is an awned grain barley. A second barley NB10425 will most likely also be released. It is a feed grain barley. Our barley research focuses on forage barley (where awnless or hooded barley is preferred), feed grain barley (where awned barleys are acceptable), malting barley (where 2-row types with pump kernels and good flavor are preferred) and food grain barley (where hulless or naked barley is preferred). Our barley program continues to distinguish itself by the high level of winter hardiness it maintains.

It has been my honor to help steward the University of Nebraska Small Grains Program for the past 34 years. I welcome my successor, Dr. Katherine Frels and hope she has as much fun as I have had. Thanks to all the stakeholders, colleagues, and the University of Nebraska for making this possible.

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