IMPROVING WHEAT VARIETIES FOR NEBRASKA

1996 STATE BREEDING AND QUALITY EVALUATION REPORT

Report to the

NEBRASKA WHEAT DEVELOPMENT, UTILIZATION
AND MARKETING BOARD

P. S. Baenziger, D. R. Shelton, and D. D. Baltensperger

January 1997

1996 STATE BREEDING AND QUALITY EVALUATION REPORT

I. INTRODUCTION

Wheat variety development research in Nebraska is cooperative between the Agricultural Research Division, IANR of the University of Nebraska-Lincoln, and the Agricultural Research Service/USDA, Northern Plains Area. Winter wheat breeding, which includes variety, line, hybrid parent, and germplasm development, is a major component of the state wheat improvement research. This report will deal only with the state portion of the total wheat breeding effort. The basic project is located in the Department of Agronomy at the University of Nebraska-Lincoln. Very important contributions come from state, and federal researchers in the department and at the Nebraska research and extension centers, from state and private researchers in South Dakota, Wyoming, Kansas, Oklahoma, Texas, and Colorado, from researchers in the Department of Plant Pathology (both state and federal), from plant pathologists located at the USDA Cereal Rust Laboratory, St. Paul, Minnesota, and USDA entomologists at Manhattan, Kansas. All of these invest time and funds in this program. Grants from the Nebraska Wheat Development, Utilization and Marketing Board provide key financial support for this research. Without the Wheat Board's support, much of the state breeding efforts would be curtailed and many of the wheat quality analyses to evaluate our breeding material would not be available.

II. THE 1996 NEBRASKA WHEAT CROP

1. Growing Conditions

The 1996 crop was planted in generally dry soil and had only average establishment. Continued dryness coupled with blowing injured fields throughout Nebraska, including the southeast and southcentral where blowing is generally not a problem. Winterkilling due to cold winter temperatures also was generally a problem throughout Nebraska on winter tender lines (e.g. TAM 200, Big Dawg). The spring was dry initially, but then had good rains. Those fields which survived the winter and early drought finished very well. In general, diseases were low in western Nebraska with soilborne mosaic virus continuing to be a major problem in southeastern Nebraska and stem rust being a major problem in southeast and southcentral Nebraska. Late spring and summer had below normal temperatures and the crop was later than normal. As such, later lines with good winterhardiness finished well as did early lines with very high yield potential (i.e. 2137 and Alliance).

2. Diseases

Foliar and head diseases are highly dependent on moisture, hence foliar diseases were important on the eastern wheat crop. In 1996, the main diseases were wheat soilborne mosaic virus, leaf rust, and stem rust. Stem rust cultures were sent to USDA Cereal Rust Laboratory and identified to be race TPMK which is virulent on Sr36 and may attack Sr6 during periods of high temperature. These stem rust genes are important genes and are used heavily in our breeding program. Vista is the main variety with Sr36, while a number of lines have Sr6 and other genes. Sr36 has been deliberately kept in the program to add genetic diversity in case of stem rust race changes that would attack other resistance genes. The stem rust situation will continue to need monitoring to determine if the resistance in Vista is adequate for its production in southcentral Nebraska. Karl 92, which generally escapes stem rust infection (matures before the disease can reduce yield) was affected by stem rust in 1996 due to the late growing season and harvest. A new disease to the United States, karnal bunt, was not found in Nebraska in 1995 or 1996.

Many diseases (wheat streak mosaic virus, barley yellow dwarf virus, leaf rust, stem rust, and various leaf blotches) can be extremely destructive under the appropriate conditions and will continue to need close monitoring, as will the survey for karnal bunt. Dr. John Watkins and Eric Kerr continue to be invaluable in disease identification, survey, and understanding.

3. Insects

In general, most insects pests were at low levels on wheat in 1996. Russian wheat aphid damage was small and required little spraying. Chinch bugs and Hessian fly were generally minor. Wheat curl mite, the vector for wheat streak mosaic virus, and aphids, the vectors for barley yellow dwarf virus, are important insect pests because they can carry devastating diseases.

4. Wheat Production

The 1996 Nebraska Wheat Crop was estimated at 73,100,000 bu which represented a 34 bu/a state average yield on 2,150,000 harvested acres. This crop was less than the 1995 crop of 86,100,000 bu (41 bu/a), but considerably better than early spring expectations. The average yield was below the five year average.

Quality determinations by CII Laboratory Services were as follows:

Wheat Protein Content (12% moisture basis)

	Wheat Protein		Test Weight	
Nebraska	1996 %	1995 %	1996 (lb/bu)	1995 (lb/bu)
Northeast	12.9	11.4	59.1	60.8
Southeast	13.0	11.7	59.0	59.8
Northcentral	13.1	11.2	59.4	60.9
Southwest	13.2	11.0	59.1	60.8
Panhandle	12.0	10.7	60.6	60.8

The quality of the 1996 Nebraska hard red winter wheat crop was exceptional. Wheat protein contents were substantially higher while test weights were 59.0 lb/bu or higher.

The predominant breadmaking procedure used in the United States is the sponge and dough process. The method requires strong gluten proteins during dough mixing and fermentation. The selection of wheat lines with the quality characteristics of medium-strong mixing properties, superior crumb grain and texture, and increased water absorption are the current priorities of the Nebraska Wheat Quality Lab. The focus on these properties will insure that the superior reputation of Nebraska wheats will be maintained in the marketplace.

5. Cultivar Distribution

Arapahoe continues to be the most popular and widely grown variety (31.7% of the state) in 1996. To put Arapahoe's acceptance in perspective, it was grown on more acres than varieties developed by other states and by commercial seed companies combined in Nebraska. Centura was the second most widely grown variety followed by Thunderbird and Karl/Karl 92.

While no wheat listed below has all of the characteristics of an ideal wheat, the diverse wheats provide the grower an opportunity to choose high yielding, high quality wheats that have resistance or tolerance to the diseases or insects prevalent in his or her region. Cultivars developed by the cooperative USDA-University of Nebraska wheat improvement program occupied 68.6% of the state acreage. Other public varieties occupied 12.1% and private varieties occupied 18.2% of the state acreage.

NEBRASKA--WHEAT VARIETIES
ESTIMATED PERCENTAGES PLANTED TO EACH VARIETY, 1990-1996

Variety	Percent					
	1990	1991	1993	1994	1995	1996
Alliance	---	---	---	---	---	2.7
Siouxland	18.7	14.5	8.2	6.4	4.0	4.7
Centura	9.6	10.4	8.5	11.1	8.0	9.2
Centurk & Centurk 78	4.4	3.3	1.6	---	1.3	---
Agripro Thunderbird	10.7	12.8	12.4	10.0	7.8	8.0
Redland	15.2	14.9	7.9	6.3	4.3	3.4
Ike	---	---	---	---	---	1.6
Lamar	---	---	---	---	---	1.2
Cody	2.4	1.8	---	---	---	---
Buckskin	1.9	2.2	4.7	5.5	4.0	5.8
Scout & Scout 66	2.2	2.4	2.8	1.6	3.4	2.4
Agripro Abilene	5.5	6.3	6.2	3.0	4.1	4.2
TAM 107	6.0	8.0	3.4	2.8	2.5	2.7
Arapahoe	1.8	8.5	28.6	32.9	33.6	31.7
Rawhide	---	---	2.1	2.0	1.0	---
Vista	---	---	---	---	4.6	3.8
Karl/Karl 92	---	---	2.1	3.8	6.9	6.9
Agripro Victory	---	1.7	1.3	---	1.0	1.2
Agripro Tomahawk	---	---	1.0	3.9	3.1	2.9
Agripro Laredo	---	---	---	---	1.2	1.1
Other Public Varieties	4.0	4.3	4.2	6.0	5.9	4.9
Other Private Varieties	3.1	2.0	1.9	3.3	1.9	0.8

6. New Cultivars

One new cultivar, Windstar, is in the process of being released by the Nebraska Agricultural Experiment Station, the South Dakota Agricultural Experiment Station, and the Northern Plains Area, Agricultural Research Service, U. S. Department of Agriculture. Windstar (formerly NE90625) is an increase of a hard red winter wheat F_3-derived line from the cross TX79A2729//Caldwell/ Brule field sel # 6/3/Siouxland which was made in 1984 by Dr. J. W. Schmidt. Windstar was identified as a line in 1990 and tested as NE90625 in Nebraska yield nurseries starting in 1991, and in the Northern Regional Performance Nursery starting in 1993. The current breeder seed originated from a purification program in 1994-1996 designed to remove off-types by roguing.

Windstar is an awned, white-glumed cultivar. Its field appearance is most similar to Rawhide and Siouxland. The canopy is moderately open and upright. The flag leaf is erect and twisted at boot stage. The foliage is blue-green, with a waxy bloom at anthesis. The leaf is pubescent. The spike is tapering in shape, moderately long to long, and middense. Under some environmental conditions, the spike may have a clavate shape same as was seen in Rawhide and Centura. The glume is short to midlong and narrow to midwide, and the glume shoulder is sloping to square. The beak is moderately short to medium with an acuminate tip. The spike is held erect to inclined at maturity and the glumes and straw have a golden color. Variants to be expected include: a) taller plants (7 to 15 cm) at a frequency of less than 1 in 1,000 which occasionally have oblique shoulders and moderately short beaks, and b) red chaffed spikes at a frequency of less than 1 in 20,000. Kernels are red colored, hard textured, and ovate. The kernel has no collar, rounded cheeks, midsize germ, midsize brush of medium length, and a narrow and shallow crease.

Windstar is a taller, semidwarf wheat with medium to late maturity. It is 1 day later than Arapahoe, 3 days later than Alliance, and 3 days later than Pronghorn. Windstar has a short coleoptile similar to Alliance, and shorter than Arapahoe and Pronghorn. Windstar is one inch shorter than Arapahoe, two inches shorter than Pronghorn, similar in height to Niobrara and Rawhide, and four inches taller than Vista. Windstar has moderately strong straw strength; better than Scout 66, Pronghorn, Alliance, Niobrara, and Arapahoe, and is similar to Rawhide. Windstar has exhibited moderate resistance to stem rust (contains Sr6 and Sr24) and moderate susceptibility to leaf rust (Lr24) and wheat streak mosaic virus. It is susceptible to the Russian wheat aphid and the Great Plains biotype of Hessian fly and to soilborne mosaic virus. The winterhardiness of Windstar is comparable to other winter wheat cultivars adapted and commonly grown in Nebraska and South Dakota. Windstar tends to have a slightly lower test weight, similar to Alliance, Niobrara, and Vista, but less than Pronghorn.

The recommended growing area for Windstar, based on current information, is the dryland wheat production areas of the Panhandle of Nebraska and western South Dakota. Using western Nebraska data from the Nebraska Fall Sown Cereal Variety Trials from 1994, 1995, and 1996 (15 environments), Windstar (52.7 bu/a) was one bu/a lower yielding than Alliance, similar to Niobrara and Vista, and four bu/a higher yielding than Arapahoe and Pronghorn. In five years of testing in the advanced trials in Nebraska (24 environments), Windstar (52.8 bu/a) was similar to Alliance; 1 bu/a higher yielding than Redland, 2 bu/a higher yielding than Vista and Niobrara; 3 bu/a higher yielding than Pronghorn; and 4 bu/a higher yielding than Arapahoe and Siouxland; 6 bu/a higher yielding than TAM107; and 9 bu/a higher yielding than Buckskin. Windstar was grown in the Northern Regional Performance Nursery in 1993 and 1994. Of the 11 entries grown in the same years, Windstar was the highest yielding line (26 environments). The main advantage that Windstar has when compared to other available wheat varieties is its consistent high yield performance in dryland production. On the basis of its pedigree, Windstar would be a complementary wheat to every variety currently grown in Nebraska and South Dakota with the exception of Siouxland.

Windstar was tested by the Nebraska Wheat Quality Laboratory for large-scale milling and baking properties from 1990 to 1995. Windstar was compared with the check varieties of Arapahoe and Scout 66. The average wheat protein content of Windstar was less than Arapahoe and similar to Scout 66. The average flour extraction on the Buhler Laboratory Mill for the experimental line was less than the check varieties. The flour ash content was greater than Scout 66 and similar to Arapahoe. The average flour protein content for the experimental line was less than that the check varieties. Dough mixing properties for Windstar are stronger than the check cultivars. Average baking absorption was similar for the experimental line and check varieties. The average loaf volume of Windstar was greater the check cultivars. The scores for the internal crumb grain and texture and external appearance were good or very good, which were superior to Arapahoe and Scout 66. The overall end-use quality characteristics for Windstar should be acceptable to the milling and baking industries.

The Nebraska Foundation Seed Division, Department of Agronomy, University of Nebraska-Lincoln, Lincoln, NE 68583 had foundation seed available to qualified certified seed producers in 1996. The U.S. Department of Agriculture will not have seed for distribution. The seed classes will be breeder, foundation, registered, and certified. Windstar will be submitted for registration and plant variety protection under P. L. 910577 with the certification option.

III. FIELD RESEARCH

1. Increase of New Experimental Lines

One experimental line is in large scale increase for possible release in 1997. In addition, two lines that were under small increase for 1996 have been given to Kansas for further testing and possible release on the basis that their performance in Nebraska was considered too variable (erratic) under our conditions, but may be useful in Kansas.

The experimental line under large scale increase is NE92662. NE92662 was derived from the cross Redland/NE82419. The pedigree of NE82419 is Trapper//CMN/OT/3/CIMMYT /Scout/4/ Buckskin sib/Homestead. It appears that NE82419 is becoming an important parent in the breeding program (see below). NE92662 is a white chaffed, awned, medium early, taller semidwarf wheat (slightly taller than Redland and similar in height to Arapahoe) with good straw strength (similar to Redland and superior to Arapahoe, Alliance, Niobrara, and Pronghorn). In the first year of testing in the state variety trial (1996), its dryland yield (54.0 bu/a) was less than Alliance (56.5 bu/a) and 2137 (56.0 bu/a), but was superior to Arapahoe (53.0 bu/a), Windstar (52.7 bu/a), Niobrara (51.5 bu/a), Pronghorn (51.4 bu/a), and Redland (50.0 bu/a). NE92662 has medium to large kernels with average test weight and protein content. NE92662 is moderately resistant to stem rust (contains genes Sr5, Sr6, Sr17, and Sr24), moderately susceptible to leaf rust (similar to Redland) and to the Great Plains biotype of Hessian fly (may be heterogeneous for the Marquillo-Kawvale resistance; it is more susceptible than Redland), and susceptible to wheat streak mosaic virus. It may have some field tolerance to wheat soilborne mosaic virus. In four years of testing, NE92622 had an average wheat protein content similar to Arapahoe and greater than Scout66. The dough mixing properties are stronger than Arapahoe and Scout66. Average loaf volumes for this line are greater than the check varieties. Based on current information NE92622 should be acceptable to the milling and baking industry. Additional testing is needed to determine if NE92662 is worthy of release.

The two lines being tested in Kansas are: NE90476 (Bennett/Brule 83 composite) and NE92458 (OK83201/Redland). Both are semidwarf wheats that performed well in the advanced trials and in the Southern Regional Performance Nursery (NE90476 was the third highest yielding line in the SRPN in 1996 though TAM107 was the second highest yielding line). NE90476 is moderately resistant to stem rust (contains genes Sr5, Sr6, Sr17, and Sr24), moderately susceptible to leaf rust,wheat streak mosaic virus, and to the Great Plains biotype of Hessian fly (may be heterogeneous for the Marquillo-Kawvale resistance; it is more susceptible than Redland), and susceptible to wheat streak mosaic virus. NE92458 is moderately resistant to stem rust (contains genes Sr5, Sr6, Sr17, and Sr24) and to the Great Plains biotype of Hessian fly, moderately susceptible to leaf rust, and susceptible to wheat streak mosaic virus. These lines were given to Kansas to determine if they may have utility in Kansas with the understanding that if they are found to have utility they will be co-released under our mutually compatible release procedures (i.e. no research and development fees, seed available from both foundation seed organizations, and Plant Variety Protection may be requested). In the past we have evaluated Kansas lines for possible release in Nebraska and this is but one form our regional cooperation.

As state experiment stations expand their focus on regional efforts, we will need to discuss how best to release lines that were initially developed in one state, but have utility in other states or niche markets. Currently, this is not a problem because many state experiment stations have compatible release procedures for hard red winter wheat. However, there are different marketing mechanisms for hard white wheat (i.e. grower organizations, or contract production via seed companies and milling companies). The market place will continue to diversify and regionalize especially for niche market wheats (purple, blue, organic, etc.), hence it should be expected that new relationships will be developed which may include marketing publicly varieties outside the state of origin in small multistate niche areas. In the soft red winter wheat area, Agripro is currently the merchandiser for a variety (Foster) developed by the University of Kentucky. Foster performs extremely well outside Kentucky and the University of Kentucky felt a commercial seed company was the best way to ensure its availability in its area of adaptation.

Three lines are under small scale increase: NE93405 (NE95707 x Thunderbird), NE93427 (NE85583/Norkan where the pedigree of NE85583 is Bez1/Centurk 78//Arthur/Centurk 78/3/Bennett), and NE93554 (NE82419/Arapahoe). NE93405 and a sister line, NE93496, are tall semidwarfs with large heads, strong straw, large kernels, and high test weight similar to their parent, Thunderbird. NE93427 is a pretty semidwarf similar to its parent Norkan. NE93554 is one of three sister lines that has had excellent performance in Nebraska (see below NIN results) and probably has the best chance for future release. In many ways, it has the adaptation, winterhardiness, disease resistance, and end-use quality of Arapahoe, but with higher yield potential.

With the release of new varieties Windstar, Pronghorn, Niobrara, Nekota, Alliance, Vista, Rawhide, Arapahoe, and co-release of Ike and TAM 200, many of the most advanced current breeding lines are not expected to be released.

2. Nebraska Variety Testing

Forty-nine entries and three seed treatments were included in some or all of the locations in the Fall Sown Small Grain Variety Tests in 1996. Twelve dryland, one irrigated, and one ecofallow nurseries were harvested for yield data. The top ten lines in 1996 for dryland production were:

Entry	Av. Yield bu/a	Entry	Av. Yield bu/a
Alliance	56.5	Windstar	52.7
2137	56.0	Niobrara	51.5
NE92662	54.0	Vista	51.5
Arapahoe	53.0	Pronghorn	51.4
NE91648	52.9	Nekota	51.3

In 1995, the top ten lines were:

Entry	Av. Yield bu/a	Entry	Av. Yield bu/a
Vista	58.0	NE90625	55.2
NE91631	58.0	Redland	54.5
TAM200	56.5	Niobrara	53.6
Karl 92	55.5	NE91648	52.8
Alliance	55.4	Arapahoe	52.7

In 1994, the top ten entries were:

Entry	Av. Yield bu/a	Entry	Av. Yield bu/a
Niobrara	52.4	Vista	51.1
Ike	52.3	Rawhide	51.1
Alliance	52.1	NE90625	50.0
Nekota	51.7	Redland	49.9
NE90479	51.2	NE89526	49.8

In 1993, the top ten entries were:

Entry	Av. Yield bu/a	Entry	Av. Yield bu/a
Niobrara	58.8	Arapahoe	55.1
Alliance	57.3	TAM107	55.1
Nekota	55.9	Karl 92	54.6
Redland	55.8	NE89526	54.3
Vista	55.6	TAM200	54.2

Of the lines tested in all locations except the irrigated test, TAM200 had the lowest grain yield (35.0 bu/a) which indicates how severe the winter was as the low yield was caused by winterkilling. Similarly, Jagger which had performed well in years with mild winters has a grain yield of 44.4 bu/a while Turkey had a grain yield of 43.5 bu.a. In 1995, Turkey had the lowest grain yield (32.8 bu/a). In 1994, TAM200 had the lowest yield (44.8 bu/a). Turkey was not tested in all locations (yielded 42.5 bu/a) and had the lowest yield in 1993 (36.4 bu/a) and in 1992. Hybrid wheat line, which have performed extremely well in the test in the past, had an average year. Quantum 566 was in the top yield group, but did not top any of the district averages. All hybrids and many varieties were not tested in all locations, hence other high yielding hybrids and varieties may be overlooked when using state-wide averages.

3. Irrigated Wheat Trials

The irrigated wheat nursery was planted in Cheyenne County on a commercial farm by Dr. D. Baltensperger. The top ten lines for grain yield were:

Karl 92	83 bu/a	Vona	75
2137	82	Rawhide	75
TAM107	78	Nekota	75
Yuma	78	Laredo	74
2163	77	Halt	73

One of the concerns with the irrigated wheat trials is that Rawhide continues to be the best irrigated wheat developed by the University of Nebraska. Using the three year average, Karl 92 (91.3 bu/a), Yuma (89.7 bu/a), and Rawhide (89.0 bu/a) are the three best irrigated wheats. With the possible exception of Yuma, none of these lines were specifically developed for irrigated production and we have not developed a truly adapted irrigated wheat.

In 1996, a change in irrigated wheat development was undertaken. 250 early generation (F_5, equivalent to our preliminary dryland observation nursery), short, semi-dwarf lines were tested at the Sidney High Plains Agricultural Laboratory using an augmented design in cooperation with Dr. Baltensperger. The 45 best lines, based on height, grain yield, and standability, from this test were advanced to a second year of irrigated and dryland testing (will be completed in 1997). High yielding semi-dwarf lines should have utility under irrigation and in our high rain-fall production areas. An additional 250 lines were planted this year in the preliminary irrigated observation nursery. A major goal of this program will be to develop high yielding, irrigated wheat varieties with and without straw for bailing. For some irrigated producers the straw is a salable by-product of their production, hence they like Rawhide. For other irrigated producers, excessive straw causes difficulties with their rotational practices and they do not like Rawhide. Though it is too early to know if this change will improve our ability to develop a truly adapted irrigated wheat, it should be more successful than our previous strategy.

4. Nebraska Intrastate Nursery

The Nebraska Intrastate Nursery (NIN) was seeded at seven locations (Mead is a single replicate for winterhardiness notes) and six locations were harvested. The nurseries this year were highly variable with the average of the 60 entries in the advanced trials ranging from 10.2 bu/a (Nelson) to 63.2 bu/a at Hemmingford. McCook was also very good (57.5 bu/a). Sidney while good (51.6 bu.a) suffered minor hail damage shortly before harvest. The high yields at Hemmingford included more volunteer wheat than normal (preplant tillage was only partially successful due to drought). North Platte was abandoned due to hail about 2 days before the nursery was mature enough to be harvested. Lincoln suffered from wind erosion and was average (31.0 bu/a) for the Nebraska trials, but showed the lack of winter/wind/drought stress tolerance in lines from other programs. Mead was generally good (better than Lincoln), but suffered from drought at finish. Nelson had very poor stands due to drought caused the wheat following alfalfa and the field having virtually no residual moisture. The yield data of the advanced nursery is attached (NEAVG is the yield average across all locations, NERANK is the rank of this mean, NEMODRNK is the rank of NEAVG_NM which is the yield average of all the locations except Nelson and Mead). One experimental line deserves particular notice, NE93554. It was the highest yielding line at Lincoln, Sidney, and McCook, and among the top four lines at Hemmingford and Mead (unreplicated trial).

1996 Nebraska Intrastate Nursery:

VARIETY	NEAVG bu/a	NERANK	NEMODRNK	NEAVG_NM	Hemming.	Lincoln	Mead bu/a	Sidney	Nelson	McCook
ARAPAHOE	41.786	25	29	52.00	64.92	41.79	27.80	55.10	14.93	46.18
NIOBRARA	40.780	34	11	54.34	62.68	30.58	20.10	61.91	7.22	62.19
PRONGHORN	42.866	18	10	54.37	70.65	31.81	30.20	50.96	9.51	64.07
NE90476	41.171	31	14	54.02	66.20	28.96	19.80	58.44	11.13	62.50
NE90479	39.258	45	49	49.03	58.52	26.24	30.20	49.31	9.21	62.07
WINDSTAR	43.342	16	16	53.82	63.52	33.25	33.90	60.72	10.88	57.78
NE91518	43.991	10	9	54.70	64.38	33.15	32.80	63.14	12.33	58.14
NE91631	42.166	22	23	53.01	58.74	39.05	26.80	59.77	14.16	54.48
NE91648	40.030	41	39	50.32	59.91	19.45	30.20	54.83	8.70	67.09
NE92456	38.915	49	48	49.10	58.92	28.25	26.70	49.15	10.40	60.07
NE92458	37.455	53	51	48.32	61.48	30.13	24.20	43.36	7.27	58.29
ALLIANCE	44.839	8	2	59.29	67.83	42.20	25.50	62.56	6.38	64.57
RAWHIDE	42.169	21	13	54.12	65.56	34.43	28.40	55.18	8.13	61.31
VISTA	40.333	40	33	51.30	59.52	27.40	26.00	57.76	10.80	60.52
NE92603	41.683	27	40	50.21	62.38	27.28	37.10	49.50	12.14	61.70
NE92608	40.613	35	28	52.12	66.23	12.51	25.90	65.11	9.29	64.64
NE92628	41.317	30	36	50.83	65.73	18.19	34.00	57.91	10.59	61.48
NE92646	39.937	42	38	50.67	65.84	21.69	28.20	59.86	8.74	55.29
NE92662	42.015	23	26	52.26	65.94	24.73	30.30	57.01	12.74	61.37
NE93405*	41.677	28	27	52.17	62.97	35.32	29.60	47.70	11.77	62.70
NE93427*	39.033	47	50	48.90	63.39	34.64	31.00	55.47	7.60	42.10
NE93496*	44.012	9	19	53.36	64.45	37.69	34.90	51.04	15.73	60.26
NE93522	43.482	14	20	53.34	62.28	41.51	36.70	50.06	10.84	59.50
REDLAND	40.906	32	42	50.11	63.15	24.76	34.70	48.97	10.28	63.57
TAM107	35.389	58	57	44.13	56.72	21.07	32.30	51.85	3.50	46.90
NE93549	43.721	13	22	53.17	67.18	37.13	36.30	53.02	13.34	55.36
NE93554*	50.208	1	1	63.42	68.97	47.49	38.60	68.94	8.98	68.27
NE93613*	45.776	6	5	56.99	67.54	30.64	34.10	64.44	12.61	65.33
NE93649	43.782	12	21	53.18	62.69	40.13	35.70	50.48	14.27	59.42
NE94407	35.509	57	59	43.71	61.09	15.60	29.90	50.78	8.33	47.35
NE94413	39.690	44	46	49.81	62.16	28.10	32.40	53.02	6.51	55.95
NE94445	42.857	19	18	53.61	68.65	30.46	36.30	54.58	6.39	60.76
NE94479*	42.638	20	15	53.84	63.08	34.97	27.10	57.83	13.36	59.49
NE94481*	43.377	15	17	53.71	67.22	27.60	28.70	60.30	16.74	59.70
NEKOTA	40.573	36	47	49.43	56.73	37.30	37.30	56.66	8.43	47.02
KARL92	38.001	52	54	45.92	56.76	26.49	36.90	51.46	7.42	48.97
NE94482*	41.344	29	37	50.70	68.64	29.44	32.50	55.87	12.76	48.86
NE94489*	40.483	37	43	49.98	63.17	21.80	33.60	57.84	9.40	57.09
NE94507	40.470	38	45	49.88	65.69	32.23	36.40	46.64	6.92	54.94
NE94512	43.252	17	30	51.79	66.01	27.38	38.90	50.74	13.46	63.02
NE94518	38.965	48	24	52.57	67.32	30.01	11.90	55.31	11.61	57.64
NE94567*	40.442	39	35	50.90	63.40	27.28	32.00	55.35	7.04	57.58
NE94577	41.766	26	31	51.65	61.95	34.54	36.10	54.64	7.88	55.49
NE94585	38.748	50	32	51.58	61.54	28.75	18.10	62.22	8.07	53.81
SIOUXLAND	45.419	7	6	56.57	65.44	38.52	34.90	60.98	11.33	61.34
SCOUT66	39.812	43	44	49.90	62.35	37.82	32.30	47.64	6.99	51.77
NE94588	43.943	11	12	54.21	66.56	37.01	37.60	55.89	9.22	57.38
NE94589	46.725	2	3	58.29	70.48	37.74	37.90	64.84	9.31	60.08

NE94632*	41.906	24	25	52.43	65.50	32.17	30.50	56.72	11.23	55.31
NE94653*	45.830	4	7	56.18	61.91	47.34	34.70	52.07	15.56	63.40
NE94654*	45.779	5	4	57.01	65.58	34.74	32.00	62.33	14.65	65.38
NE94655	46.193	3	8	55.44	61.69	48.17	39.20	52.58	16.19	59.33
NE94661	34.634	59	56	44.24	60.73	15.09	26.70	48.50	4.15	52.63
NE94665	37.052	54	58	43.80	59.48	24.53	39.20	42.68	7.91	48.51
NE94666	35.857	56	55	44.67	56.56	23.23	27.70	43.92	8.76	54.97
NE94673	40.788	33	34	50.97	57.82	35.67	29.10	47.62	11.74	62.78
NE94685	39.188	46	41	50.18	64.55	30.27	26.10	52.01	8.31	53.89
CENTURA	36.139	55	53	47.11	60.10	31.28	18.20	44.43	10.18	52.64
CHEYENNE	38.084	51	52	48.16	58.85	25.27	26.90	52.48	8.96	56.05
BUCKSKIN	33.520	60	60	41.91	52.98	25.71	25.50	51.61	7.99	37.33
GRAND MEAN	0.000				63.20	30.9	7	54.55	10.17	57.46
LSD	0.000				4.89	16.6	2	5.70	3.57	20.70

* Advanced to USDA regional nurseries.

The Nebraska Wheat Quality Lab analyzed for milling and baking characteristics 36 advanced experimental lines and check varieties from the 1995 NIN which were retained for further testing in the 1996 NIN. Again this year the Nebraska Wheat Quality Lab evaluated wheat samples from the NIN and Triplicate Nursery. In the NIN wheat protein contents (14%mb) of the 34 samples ranged from 10.5% (NE90625) and 12.8% (NE93405). Wet, cool growing conditions in 1995 contributed to lower protein contents. Strong dough mixing properties, as determined with the Mixograph, were evident for NE90476, NE90479, NE90625, NE91631, NE92608, NE92646, NE92662, and NE93522. Experimental lines with notable baking performance included NE90476, NE90479, NE90625, NE92456, NE92608, and NE92662.

The Nebraska Wheat Quality Lab analyzed for milling and baking characteristics 24 advanced experimental lines and check varieties from the 1995 Triplicate Nursery which were advanced for further testing in the 1996 NIN. The Nebraska Wheat Quality Lab evaluated nine samples as having notable promise for end-use processing. Breads baked from NE93403, NE93405, NE93451, NE93496, NE93522, NE93535, NE93549, NE93554, NE93597, and N931005 have loaf volumes in excess of 900cc. Additionally, the external appearance and internal characteristics of these experimental lines were scored good to very good. Two lines, NE93406 and NE93427, were rated as having sticky dough handling properties after mixing. These and three other lines, NE93435, NE93477, and NE93618, made less than satisfactory bread.

The Triplicate Nursery was comprised of 28 wheat samples. Wheat protein contents (14%mb) ranged from 9.8% (NE94482) to 13.6% (NE94661). Dough mixing characteristics indicated that NE94512 and NE94589 had the strongest tolerance properties, a trait desired by the milling and baking industries. After baking two samples were evaluated as having notable promise: NE94507 and NE94653. The external appearance and internal characteristics of these experimental lines were scored as good. Other lines in the Triplicate Nursery were evaluated as less than satisfactory. NE94661 had soft milling characteristics and choked (plugged) the Buhler mill. Two other lines (NE94413 and NE94577) were rated as having sticky dough-handling properties after mixing.

Each wheat sample from the Triplicate and NIN Nurseries was evaluated by growing location on the Single Kernel Characterization System 4100, which determined individual kernel moisture content, weight, diameter, and hardness. Results for each characteristic were expressed as an average of 300 kernels and as a distribution. Three experimental wheat lines (NE94407, NE94654, and NE94567) were scored as mixed wheat. One sample (NE94661) scored as soft wheat. At one or more locations the following lines were scored as mixed wheat: NE90476 and NE90479. Results from the SKCS 4100 will be used to make selections for advancement in the future. This device may be adopted by the Federal Grain Inspection Service as part of the grain grading system. Also this device has the potential to select wheat lines that are less effected by growing conditions and have uniform seed size.

The 1995 NIN data follow:

	Yield (bu/a)									
VARIETY	Linc.	DeWee	N.Plat	Sidney	Hemming	McCook	Average	Aver.-Linc	RANKAVG	RANKAVG_L
ARAPAHOE	16.91	33.01	19.29	64.53	68.88	53.09	42.618	47.760	47	46
N93L005	16.39	36.80	22.05	69.18	70.62	57.50	45.423	51.230	39	41
NE88584	17.86	32.61	23.93	70.27	75.06	58.78	46.418	52.130	37	36
ALLIANCE	12.98	39.73	34.03	71.49	66.64	65.71	48.430	55.520	30	27
RAWHIDE	14.23	37.45	38.98	75.29	83.25	59.95	51.525	58.984	13	8
NIOBRARA	16.06	37.97	29.87	72.68	70.38	58.46	47.570	53.872	32	32
NE90476*	20.26	41.35	42.31	72.52	79.51	65.78	53.622	60.294	4	4
NE90479	16.79	32.21	31.69	42.64	73.44	50.61	41.230	46.118	49	51
NE90524	19.42	29.74	29.63	67.54	77.39	60.60	47.387	52.980	33	33
NE90625	17.95	37.86	28.04	74.76	78.02	72.37	51.500	58.210	14	13
KARL92	22.28	30.52	39.20	66.12	82.72	51.69	48.755	54.050	28	31
NE91515	19.93	34.89	31.00	68.88	67.77	58.28	46.792	52.164	35	34
NE91518	29.95	32.54	37.26	78.47	75.25	54.73	51.367	55.650	17	25
NE91631*	17.81	50.24	39.28	80.24	70.62	69.76	54.658	62.028	2	2
NE91648*	17.59	46.47	42.71	70.63	67.78	68.98	52.360	59.314	7	7
NE91651	19.64	39.28	42.18	75.90	79.09	57.00	52.182	58.690	9	10
SCOUT66	7.02	23.92	10.09	41.66	52.25	41.27	29.368	33.838	60	60
NE92456	19.60	33.34	41.54	75.90	75.94	63.89	51.702	58.122	11	14
NE92458*	12.37	27.13	58.05	80.63	67.26	67.98	52.237	60.210	8	5
NE92466	16.73	24.34	52.59	64.98	77.72	55.30	48.610	54.986	29	30
NE92477	19.58	32.66	38.22	60.54	62.31	55.44	44.792	49.834	43	43
CHEYENNE	9.41	32.60	10.05	56.22	66.18	54.42	38.147	43.894	59	58
NE92522	16.36	30.46	38.73	69.69	75.03	73.30	50.595	57.442	21	18
NE92603	21.43	43.77	33.45	76.10	69.69	59.40	50.640	56.482	20	21
NE92608	13.78	29.11	39.06	79.04	77.38	61.49	49.977	57.216	25	19
NE92614	19.04	26.90	22.35	69.34	75.08	53.42	44.355	49.418	44	44
REDLAND	21.39	43.52	38.18	72.61	76.04	69.76	53.583	60.022	5	6
NE92628*	17.03	46.08	54.43	79.71	80.63	68.89	57.795	65.948	1	1
NE92646*	14.31	27.17	50.71	75.03	73.17	63.87	50.710	57.990	19	16
NE92652*	24.13	37.56	32.73	68.19	76.73	60.85	50.032	55.212	24	28
NE92662*	24.21	36.45	42.20	73.25	74.21	64.48	52.467	58.118	6	15
NE93403	13.17	30.86	18.12	71.88	60.67	64.64	43.223	49.234	45	45
BUCKSKIN	7.70	29.87	10.08	68.89	69.74	50.77	39.508	45.870	57	54
NE93405*	22.36	38.59	29.25	60.16	74.95	57.49	47.133	52.088	34	37
NE93406	15.44	26.36	19.55	58.84	72.98	48.76	40.322	45.298	54	55
NE93427*	16.43	33.13	46.54	76.14	71.46	66.46	51.693	58.746	12	9
NE93435	19.60	35.05	45.63	81.07	81.48	48.43	51.877	58.332	10	12
TAM107	20.12	33.98	44.66	69.76	67.29	42.07	46.313	51.552	38	39
NE93451	14.41	34.91	16.87	55.00	70.05	41.84	38.847	43.734	58	59
NE93452	13.04	29.07	14.95	63.78	81.81	43.58	41.038	46.638	51	50
NE93462	12.35	32.63	34.32	62.72	73.00	57.51	45.422	52.036	40	38
NE93473	13.88	32.18	28.17	49.05	68.08	52.96	40.720	46.088	53	52
NE93477	19.71	31.67	18.67	54.92	74.75	54.58	42.383	46.918	48	48
VISTA	15.74	42.99	42.76	71.51	71.43	64.10	51.422	58.558	15	11
NE93496	18.50	25.86	34.82	68.10	71.54	60.41	46.538	52.146	36	35
NE93522	22.34	38.10	44.05	58.36	73.75	66.60	50.533	56.172	22	22
NE93535	16.55	30.71	32.07	68.65	71.46	52.19	45.272	51.016	41	42
NE93536	11.72	19.25	34.21	61.00	69.79	45.12	40.182	45.874	55	53

NE93549	16.08	25.32	48.84	71.02	74.61	58.61	49.080	55.680	26	24
NE93554*	22.26	33.94	42.34	69.30	67.98	64.56	50.063	55.624	23	26
NE93597	19.25	29.02	23.86	66.48	65.31	51.98	42.650	47.330	46	47
NE93598	24.23	39.27	34.71	70.73	76.96	58.84	50.790	56.102	18	23
NE93613*	21.15	41.19	38.87	72.24	85.28	66.94	54.278	60.904	3	3
NE93618	18.88	31.86	13.21	54.74	73.23	53.06	40.830	45.220	52	56
NE93649	14.52	33.35	35.24	75.14	70.07	61.55	48.312	55.070	31	29
NE93669	11.55	36.95	22.75	76.34	81.98	64.56	49.022	56.516	27	20
VBF0168	20.15	37.48	44.23	70.50	78.13	57.87	51.393	57.642	16	17
SXLD/RAM-1	12.97	33.95	17.80	62.87	74.40	44.39	41.063	46.682	50	49
SXLD/RAM-2	15.65	28.14	17.18	60.38	66.88	51.61	39.973	44.838	56	57
SIOUXLAND	13.51	38.86	21.56	70.84	75.48	49.90	45.025	51.328	42	40
GRAND MEAN	17.26	34.04	32.82	68.07	73.01	57.97	47.195	53.18		
CV	15.09	12.88	20.74	6.03	8.32	7.14	11.700			
LSD	3.64	6.13	9.51	5.74	8.49	8.69	7.033			

* Advanced to USDA regional nurseries.

In 1994 the top nine lines were:

	Yield (bu/a)						Rank
VARIETY	Linc.	Holstein	N.Plat.	Sidney	Hemm.	Average	
Alliance	59.298	64.051	56.699	80.950	64.138	65.027	5
NE90476*	64.202	70.670	52.825	73.350	66.113	65.432	4
KARL92	68.323	68.665	51.202	76.900	72.038	67.426	1
NE91518	63.809	67.698	54.786	79.417	63.900	65.922	2
NE91648*	64.565	64.621	52.090	82.350	58.700	64.465	7
NE92522*	65.408	62.558	61.119	74.283	64.500	65.574	3
NE92608	68.684	64.275	56.692	71.233	60.925	64.362	9
NE92652	62.466	63.103	53.215	76.567	69.163	64.903	6
NE92605	64.647	70.610	54.429	70.067	62.113	64.373	8

* Advanced to USDA Regional Nurseries for further testing.

In 1993, the top ten lines in the NIN were:

	Yield (bu/a)						Rank
VARIETY	Linc.	ClayC.	N.Plat.	McCook	Hemm.	Average	
NE88584	37.46	30.00	53.54	49.92	73.25	48.834	6
Alliance	34.73	27.42	59.56	45.02	79.90	49.326	3
NE90476	31.68	34.64	50.86	54.78	71.41	48.674	7
NE90479	33.64	33.46	57.79	55.67	66.52	49.416	2
NE90524	34.70	28.10	54.33	57.69	67.11	48.386	9
NE90574	31.93	24.14	60.43	55.55	72.57	48.924	5
NE89671	34.84	23.80	66.17	46.88	77.65	49.868	1
NE91648	25.62	28.64	61.25	54.89	72.91	48.662	8
NE91651	24.55	29.26	60.03	63.35	67.43	48.924	4
HBF0263	24.54	36.62	55.86	52.64	70.44	48.020	10

5. Nebraska Triplicate Nursery

The same comments about the NIN data apply to the Nebraska Triplicate Nursery (NTN). The data for the 1996 NTN follows:

VARIETY	Linc.	Nelson	McCook	Sidney	Hemmin.	Mead	NEAVG	RANK	NAVG_NM	Rank_NM
			bu/a						bu/a	
NE95410	41.763	7.353	55.045	39.877	62.028	27.800	38.978	43	49.678	42
NE95413	21.475	4.637	29.733	51.879	55.092	20.100	30.486	60	39.545	59
NE95417	41.448	10.810	59.308	44.215	60.214	30.200	41.033	29	51.296	32
NE95444	42.805	10.605	49.551	40.264	67.629	19.800	38.442	48	50.062	40
NE95447	44.164	9.791	57.479	48.450	62.160	30.200	42.041	19	53.063	19
NE95450	34.133	7.318	54.463	55.587	61.881	33.900	41.214	28	51.516	29
NE95451	34.386	6.400	48.816	52.218	62.650	32.800	39.545	38	49.518	43
NE95473	40.086	13.979	60.702	56.560	67.698	26.800	44.304	8	56.262	6
NE95480	32.966	6.191	46.231	46.371	58.112	30.200	36.679	57	45.920	56
NE95481	32.065	8.805	50.580	60.539	60.531	26.700	39.870	36	50.929	34
NE95482	37.066	5.638	59.314	52.262	63.137	24.200	40.270	34	52.945	21
NE95489	43.032	4.639	60.875	52.375	63.399	25.500	41.637	21	54.920	10
NE95499	17.201	2.170	44.236	39.811	53.613	28.400	30.905	59	38.715	60
NE95506	35.118	12.814	57.036	46.268	58.760	26.000	39.333	40	49.296	46
ARAPAHOE	40.904	14.422	57.987	57.280	62.784	37.100	45.080	3	54.739	11
NE95508	37.905	13.332	55.431	48.545	60.811	25.900	40.321	33	50.673	36
NE95509	41.317	13.829	64.296	50.502	61.161	34.000	44.184	9	54.319	13
NE95510	43.182	11.201	57.603	49.587	61.416	28.200	41.865	20	52.947	20
NE95518	47.327	6.536	58.274	55.760	60.409	30.300	43.101	15	55.443	7
NE95520	32.391	-0.028	51.370	57.564	64.644	29.600	39.257	41	51.492	30
NE95521	46.353	9.463	55.300	49.729	61.690	31.000	42.256	18	53.268	18
NE95526	46.951	7.365	60.231	60.593	59.719	34.400	44.877	6	56.874	3
NE95530	23.925	6.021	52.430	55.506	61.746	36.700	39.388	39	48.402	47
NE95535	33.339	12.854	55.720	54.451	57.038	34.700	41.350	27	50.137	39
NE95536	45.547	9.528	61.431	49.914	63.308	32.300	43.671	11	55.050	9
NE95537	33.554	5.148	54.530	53.527	65.550	36.300	41.435	24	51.790	28
NE95538	36.875	14.204	62.530	47.682	62.998	38.600	43.815	10	52.521	24
NE95541	28.958	9.756	46.922	46.460	57.782	34.100	37.330	52	45.031	58
NE95543	29.099	10.156	48.570	51.618	57.829	35.700	38.829	44	46.779	53
REDLAND	42.548	13.309	64.097	46.319	60.895	29.900	42.845	16	53.465	17
NE95544	31.944	7.224	47.592	50.459	62.998	32.400	38.770	46	48.248	49
NE95546	47.525	4.909	52.177	59.318	59.933	36.300	43.360	14	54.738	12
NE95553	46.567	7.050	56.452	58.839	65.054	27.100	43.510	12	56.728	4
NE95567	37.618	8.822	48.648	51.179	56.152	28.700	38.520	47	48.399	48
NE95572	34.925	3.793	52.998	40.912	62.806	37.300	38.789	45	47.910	50
NE95575	36.558	17.078	65.250	53.777	59.811	36.900	44.896	5	53.849	14
NE95576	37.022	10.413	49.953	54.230	64.409	32.500	41.421	25	51.404	31
NE95577	37.390	7.323	61.957	47.825	61.363	33.600	41.576	23	52.134	27
NE95583	27.355	1.536	44.037	53.171	59.355	36.400	36.976	56	45.980	55
NE95587	42.775	11.204	53.713	51.095	62.594	38.900	43.380	13	52.544	23
NE95589	43.625	5.704	59.288	36.401	57.957	11.900	35.813	58	49.318	45
NE95593	49.885	2.880	57.971	37.889	64.982	32.000	40.935	31	52.682	22
NE95632	46.250	8.856	63.001	62.476	64.546	36.100	46.872	1	59.068	1
NE95650	40.806	7.394	56.033	52.676	59.159	18.100	39.028	42	52.169	26
KARL 92	35.228	10.108	58.063	50.640	57.128	34.900	41.011	30	50.265	37
NE95656	48.066	9.124	58.451	58.608	68.351	32.300	45.817	2	58.369	2
NE95668	37.847	6.078	54.680	48.747	59.508	37.600	40.743	32	50.196	38

NE95676	40.547	4.517	48.149	35.352	61.092	37.900	37.926	50	46.285	54
NE95683	46.091	9.194	51.512	56.671	59.636	30.500	42.267	17	53.478	16
NE95684	43.400	8.374	58.519	62.178	62.697	34.700	44.978	4	56.699	5
NE95685	40.755	7.279	44.668	39.374	57.890	32.000	36.994	55	45.672	57
NE95686	35.572	7.486	53.447	48.066	65.727	39.200	41.583	22	50.703	35
NE95697	42.670	7.210	49.172	53.168	59.133	26.700	39.676	37	51.036	33
CRL87049	47.548	8.555	54.908	60.161	57.838	39.200	44.702	7	55.114	8
N94L005	37.179	8.092	47.448	46.767	58.794	27.700	37.663	51	47.547	51
N94L036	37.523	6.824	46.050	49.658	54.593	29.100	37.291	53	46.956	52
N94L154	28.895	6.163	53.126	55.161	60.783	26.100	38.371	49	49.491	44
N94L205	34.148	5.887	51.111	50.164	63.481	18.200	37.165	54	49.726	41
N94L212	41.220	7.121	53.474	56.960	62.485	26.900	41.360	26	53.535	15
TAM107	37.784	5.441	54.333	58.695	58.626	25.500	40.063	35	52.360	25

Twenty-one lines were advanced to the Nebraska Intrastate Nursery which is normal for advancement from this nursery. The Nebraska Wheat Quality Laboratory milled and baked the 59 wheat samples from the 1995 Duplicate Nursery which were tested in the 1996 NTN. Wheat protein contents (14%mb) ranged from 10.6% (NE95684) to 13.4% (NE95535). Strong dough mixing properties were noted for NE95410. Five samples were evaluated as having notable promise: NE95417, NE95451, NE95473, NE95508, and NE95510. These experimental lines had high loaf volumes. Additionally, the external appearance and internal characteristics of these experimental lines were scored as good or very good in at least one category. Other lines were evaluated as less satisfactory. NE95526 had soft milling characteristics and plugged the Buhler mill. Two other lines (NE95535 and NE95538) had poor milling characteristics. Two lines, NE95575 and NE95577, were rated as having sticky dough handling properties after mixing. Bread made from the following lines was rated as poor in one or more quality characteristics: NE95450, NE95575, NE95577, NE95583, and NE95589.

Each wheat sample from the Duplicate Nursery was evaluated by location on the Single Kernel Characterization System 4100. At Sidney the following hard red winter wheat lines were scored as soft wheat: NE95526, NE95538, and NE95684. Eight other samples were scored as mixed wheat. Analyses of samples, grown at Hemingford, indicated that one line (NE95538) scored as soft, while five lines were rated as mixed wheat. Two lines from Clay Center (NE95526 AND NE95538) scored soft and five lines scored as mixed wheat. Evaluation of experimental wheat lines from North Platte indicated eight lines were scored as mixed wheat. The lines that scored as soft wheat (NE95526 AND NE95538) also presented problems during Buhler milling.

The 1995 yield data are:

			Yield (bu/a)						
ENTRY	RANK	Entry	Average	Hemming	DeWeese	McCook	Mead	N.Platte	Sidney
1	25	ARAPAHOE	60.913	71.37	39.10	59.615	34.40	64.71	69.77
2	58	NE94402	47.665	73.10	25.57	47.525	26.90	53.95	38.18
3	51	NE94403	51.504	70.23	31.37	49.980	25.40	53.07	52.87
4	41	NE94406	54.871	71.60	26.39	49.165	28.30	62.11	65.09
5	23	NE94407	61.138	78.07	41.59	54.060	35.60	59.61	72.36
6	29	NE94411	59.940	69.07	35.51	55.640	29.70	60.62	78.86
7	12	NE94413	63.772	67.83	35.48	67.460	34.80	75.86	72.23
8	31	NE94414	58.818	69.30	30.80	60.460	27.80	64.42	69.11
9	33	NE94415	57.323	84.37	28.28	54.845	28.90	54.64	64.48
10	56	NE94422	50.254	75.17	21.87	45.930	28.30	52.93	55.37
11	10	NE94431	64.858	75.07	37.05	71.470	30.80	66.95	73.75
12	46	NE94433	53.318	85.70	20.35	41.850	27.70	63.00	55.69
13	55	NE94434	51.019	72.47	24.48	50.415	31.50	60.00	47.73

14	60	NE94441	42.580	65.90	30.07	46.500	33.50	38.31	32.12
15	27	NE94444	60.322	85.07	33.95	60.550	35.30	56.25	65.79
16	8	NE94445	66.240	69.57	47.05	65.470	36.90	76.19	72.92
17	47	NE94458	53.280	72.60	35.23	42.560	47.20	69.31	46.70
18	35	NE94471	56.857	75.87	35.10	58.515	39.10	56.80	58.00
19	4	NE94479	68.127	81.43	47.13	72.015	43.50	65.93	74.13
20	36	KARL92	56.773	75.70	32.64	57.355	36.80	54.01	64.16
21	2	NE94481	71.336	79.93	52.15	73.170	53.00	72.29	79.14
22	1	NE94482	74.930	81.60	61.87	79.170	45.50	72.78	79.23
23	5	NE94489	67.586	85.93	35.31	63.350	33.70	68.77	84.57
24	52	NE94492	51.477	74.30	32.29	40.285	26.90	54.43	56.08
25	32	NE94507	57.705	69.33	28.41	54.185	24.60	66.14	70.46
26	20	NE94512	61.961	62.93	35.58	63.235	32.50	72.31	75.75
27	19	NE94518	62.057	90.37	38.06	51.865	31.80	65.00	64.99
28	40	NE94535	54.901	75.67	31.92	52.725	32.60	51.42	62.77
29	50	NE94538	52.068	70.57	31.97	46.460	27.30	56.84	54.50
30	48	NE94539	53.032	62.17	25.71	46.250	23.90	62.96	68.07
31	57	NE94541	48.399	65.90	28.03	40.855	20.00	46.14	61.07
32	6	NE94567	67.147	82.93	32.30	64.345	30.00	71.44	84.72
33	11	NE94577	64.340	72.30	41.14	59.920	28.00	75.96	72.38
34	43	NE94579	54.415	82.07	35.32	49.875	23.40	52.94	51.87
35	24	NE94585	61.077	71.83	34.56	61.125	38.90	67.16	70.71
36	34	NE94588	56.862	81.67	25.78	48.000	31.50	65.79	63.07
37	28	NE94589	60.076	76.90	34.60	53.420	24.90	58.42	77.04
38	38	NE94591	55.883	82.90	32.48	53.135	26.30	55.75	55.15
39	42	NE94592	54.747	65.87	33.50	46.565	30.10	69.86	57.94
40	59	SCOUT66	46.228	66.87	32.46	45.200	13.30	41.01	45.60
41	39	NE94596	55.246	72.10	25.11	44.820	21.40	62.19	72.01
42	45	NE94612	53.541	79.90	22.80	45.845	25.70	65.41	53.75
43	3	NE94631	70.199	75.80	50.26	65.585	38.60	77.88	81.47
44	9	NE94632	65.362	75.70	42.67	60.630	36.50	71.59	76.22
45	14	NE94653	63.537	67.13	36.93	62.225	44.00	69.64	81.76
46	21	NE94654	61.771	68.60	40.19	66.495	39.90	60.83	72.74
47	7	NE94655	66.888	76.77	38.34	69.500	34.30	76.57	73.26
48	15	NE94661	62.582	82.43	26.43	55.170	30.10	81.34	67.54
49	22	NE94665	61.380	72.77	35.85	63.220	27.80	68.19	66.87
50	26	NE94666	60.527	77.17	31.32	66.775	37.40	64.85	62.52
51	49	NE94669	52.889	61.00	32.47	50.015	33.60	62.65	58.31
52	37	NE94671	56.332	79.83	24.79	54.920	23.90	59.29	62.83
53	16	NE94673	62.330	72.40	30.40	63.140	32.50	75.09	70.62
54	30	NE94677	59.639	67.47	34.75	63.835	28.70	65.01	67.13
55	17	NE94678	62.302	86.47	31.79	64.590	23.90	63.32	65.34
56	18	NE94685	62.225	77.37	43.87	56.705	28.90	67.80	65.38
57	53	NE94686	51.311	70.20	32.25	42.705	26.60	53.19	58.21
58	54	NE94689	51.140	77.17	17.06	44.400	17.40	53.39	63.68
59	13	N87V106-L	63.573	84.70	36.39	58.965	40.40	72.99	64.82
60	44	TAM107	53.667	68.57	33.21	42.245	30.00	57.53	66.78
		GRAND MEAN	54.483	74.75	33.82	55.772		63.08	65.26
		CV	10.274	10.60	13.20	7.694		11.34	8.86
		LSD	8.346	13.44	6.25	9.012		10.02	8.10

In 1994, the top ten lines were:

VARIETY	Yield (bu/a) Linc.	Holstein	N. Plat.	Sidney	Hemming.	StateAvg.	RANK	McCook* (bu/a)
NE93403	69.917	67.313	57.273	71.767	61.216	57.824	3	19.460
NE93405	63.122	65.947	52.606	65.050	68.664	56.780	6	25.290
NE93406	69.536	56.157	51.506	71.783	63.404	56.221	10	24.940
NE93427	65.134	60.800	54.719	75.067	59.117	56.401	8	23.570
NE93435	67.854	60.292	52.415	74.117	69.735	57.669	4	21.600
NE93536	71.445	64.055	53.131	66.800	62.607	56.736	7	22.375
NE93554	74.663	69.891	54.148	76.433	61.980	60.249	1	24.380
NE93613	67.562	63.200	58.332	76.533	60.762	57.552	5	18.920
NE93669	72.568	67.531	53.511	72.167	58.603	57.830	2	22.600
Tam107	71.490	57.730	52.568	73.400	65.484	56.349	9	17.420

In 1993, the top ten lines were:

VARIETY	Yield (bu/a) Linc.	ClayC.	N.Plat.	McCook	Hemm.	Average	Rank
NE92455	30.93	24.24	64.10	67.35	64.10	50.144	5
NE92462	32.72	24.68	61.38	63.16	66.99	49.786	7
NE92522	26.56	27.55	60.57	61.54	72.19	49.682	8
NE92538	33.85	23.95	59.19	69.58	67.54	50.822	3
REDLAND	28.12	22.83	60.69	62.06	72.66	49.272	10
NE92578	28.24	29.18	66.31	52.02	72.06	49.562	9
NE92605	29.37	24.24	66.31	60.45	72.86	50.646	4
NE92614	29.07	23.58	63.13	65.24	69.00	50.004	6
NE92628	31.31	25.77	70.94	69.30	71.99	53.862	1
NE92662	30.27	30.79	61.78	59.65	72.00	50.898	2

6. Regional Nurseries

The Southern Regional Performance Nursery (SRPN) and Northern Regional Performance Nursery (NRPN) were harvested at Sidney and Hemmingford. Yields were as follows:

SRPN:

Variety	Sidney	Hemming. bu/a	Avg.	Rank
KHARKOF	47.39	49.11	48.250	42
SCOUT 66	51.77	63.49	57.630	26
TAM107	73.24	62.39	67.815	4
KS93U206	64.99	63.31	64.150	12
OK91P648	54.73	50.47	52.600	34
OK93P735	50.27	60.01	55.140	31
OK93P634	49.71	53.74	51.725	38
OK92403	45.92	54.71	50.315	41
TX91D6913	64.44	57.98	61.210	18
TX91D6991	60.26	68.64	64.450	11
TX92V3108	49.59	51.19	50.390	40
HBI0531-A2	63.77	70.09	66.930	7
TX93V5919	64.53	61.93	63.230	15

TX93V5922	46.73	49.01	47.870	43
TX93V4927	61.45	42.79	52.120	36
TX92V2519	63.46	48.26	55.860	29
TXGH12588-105	72.72	54.71	63.715	14
CO910424	78.77	64.42	71.595	1
CO10748	78.26	57.17	67.715	5
KS91H153-2	64.44	50.25	57.345	27
KS941064-3	28.48	57.84	43.160	44
KS941064-6	25.34	58.32	41.830	45
KS940935-721	44.31	60.87	52.590	35
KS940935-1255	45.08	61.17	53.125	32
KS85W663-116M	47.72	57.80	52.760	33
KS84W063-9393M	61.73	57.19	59.460	23
NE90476	43.88	58.32	51.100	39
NE92458	53.30	50.35	51.825	37
NE92646	73.83	61.03	67.430	6
NE93405	58.20	61.85	60.025	22
NE93427	57.77	63.96	60.865	20
AP7510	59.09	60.99	60.040	21
BIG DAWG	72.47	60.34	66.405	8
T702	71.63	57.64	64.635	10
T838	78.62	63.37	70.995	2
T812	70.70	61.59	66.145	9
T861	54.03	61.65	57.840	25
T89	63.80	58.49	61.145	19
G1878	57.74	53.26	55.500	30
ARAPAHOE	62.44	54.74	58.590	24
REDLAND	61.78	62.59	62.185	16
NE92652	72.67	63.82	68.245	3
N94L187	57.09	57.27	57.180	28
N93L067	65.67	57.83	61.750	17
N93L068	66.99	60.92	63.955	13
GRAND MEAN	59.13	58.15		
CV	14.29	9.05		
LSD	11.47	14.64		

NRPN:

Entry	Variety	Sidney	Hemming	AVG.	Rank
			bu/a		
1	CI1442	49.241	53.178	51.210	29
2	CI17439	53.205	53.276	53.241	27
3	PI511307	44.260	62.534	53.397	26
4	SD89153	59.175	59.822	59.499	13
5	SD91192	61.085	59.954	60.520	11
6	SD92107	63.848	60.647	62.248	6
7	SD92124	57.900	60.031	58.966	15
8	SD92174	63.488	51.969	57.729	17
9	SD92191	61.925	64.375	63.150	5
10	SD92227	56.286	67.545	61.916	7
11	SD92266	63.031	66.435	64.733	3
12	ND9257	51.746	51.195	51.471	28
13	ND9272	55.305	56.655	55.980	22
14	ND9274	53.945	53.871	53.908	23

15	NE92628	57.382	64.107	60.745	10
16	NE92662	57.319	66.005	61.662	8
17	NE92652	64.525	57.986	61.256	9
18	NE93554	65.650	62.206	63.928	4
19	NE93613	59.067	58.274	58.671	16
20	XNH1798	63.914	68.030	65.972	2
21	XNH1800	72.976	59.842	66.409	1
22	MT88046	43.911	53.505	48.708	30
23	MTS92042	54.993	52.774	53.884	24
24	ID0467	52.882	59.972	56.427	19
25	ID0483	35.723	71.500	53.612	25
26	AMP3JP4A7A	53.748	58.327	56.038	21
27	AMQ3KC4C7B	65.852	53.345	59.599	12
28	AMQ3NQ4A7D	61.216	57.127	59.172	14
29	AMQ3KF4B7A	61.138	51.698	56.418	20
30	ARAPAHOE	55.299	60.130	57.715	18
	GRAND MEAN	57.334	59.211	0.000	
	CV	7.316	7.710	0.000	
	LSD	11.882	6.232	0.000	

In this nursery, the hybrids (XNH lines) continue to perform well as do many of the Nebraska experimental lines.

7. Multiple-Location Observation Nursery

Five replications (locations) of this nursery were harvested, but only four locations were used for selection. North Platte was lost to hail and the data from Nelson was too variable to be used. With the size of the nursery, spatial variation continues to be a problem at many locations. This necessitated ranking the lines on the basis of their yield data as well as their relative performance of nearest Arapahoe check plots. Enhanced statistical analyses for these trials continue to be sought. Fifty-six lines (including five lines from Dr. C. J. Peterson's breeding efforts) were advance to the Nebraska Triplicate Nursery. The improved design (started in 1995) of having one replicated check throughout the nursery was very important in determining the relative performance.

8. Early Generation Nurseries

a. Single-plot Observation Nursery

The 1995 head row nursery was one of the best in years. Seventeen hundred and eight lines including checks were evaluated at Lincoln in 1996 with an additional 523 lines evaluated at Mead. Of this group, 451 lines were submitted for Quadrumat Junior milling, flour protein content, and dough mixing properties. A major improvement in this nursery has been the planting of a single 10' row at Mead for every plot planted at Lincoln. Hence, if one nursery is lost, a second row is available for selection and harvesting. As in the past, the turn-around time was excellent (all quality evaluations completed by the end of August). On the basis of agronomic and quality performance, 300 lines were selected for further testing. The cooperative test became larger with the addition of about 30 lines from Dr. Peterson.

b. Headrow Nursery

Over 41,000 headrows were planted at Mead. In general, the headrow nursery was adequate, but heavy weed infestations on a new field and late planting posed a problem. Over 1800 rows were selected and 1798 lines were advanced to the observation nursery. In addition, 250 strong strawed semi-dwarf lines were directly advanced to an irrigated observation nursery in cooperation with Dr. David Baltensperger.

a. F_3 bulk hybrids

The F_3 bulk hybrid nursery contained 816 bulks and check plots and were planted at Mead and Sidney. Most bulks survived the winter and were good for selection. Heads were selected from the Mead bulks and the seed quality would be considered as average. The number of F_3 bulks is probably above the optimal size, but this is due to a gift of segregating materials from North Dakota State University where the winter wheat breeding program has been closed and our planting segregating red and white F_3 and F_4 bulks. The frequency of white segregants should be higher in F_4 bulks than in F_3 bulks. Over 40,000 head rows were selected for fall planting. The bulk of the headrows were planted early, hence should be well established for the winter. The project goal remains to have sufficiently good segregating F_3 material to select about 40 - 45,000 headrows.

b. F_2 bulk hybrids

The F_2 bulk hybrid nursery contained 730 bulks and check plots. These bulks generally survived the winter, but seemed to be hurt by drought. In order to control weeds, the Mead nursery follows early soybeans. This rotation is better for weed control that wheat fallow wheat, but does deplete residual soil moisture, hence the droughty appearance in this part of the field. We are now using shorter season soybeans, are requiring irrigation potential, and are using better herbicides to control weeds. Ideally, the Mead rotation would be wheat, summer annual (corn, soybeans, sorghum, etc.), summer annual, spring oats, and wheat. Oats are a better preceding crop because they use much less moisture. In order to quickly complete harvest, the bulks were harvested by combine (hence will include some mixed seed). Harvesting four rows gave ample seed for planting the F_3 bulk nursery in 1996 at Mead and at Sidney. In many cases there was sufficient seed to share with other programs. Over 300 bulks were sent to South Dakota State University, which lost their bulks to winterkill. An additional, 25 to 30 bulks were shared with Agripro and with Texas A&M. We received about 30 bulks from Texas A&M for use in our program. It is hoped that this germplasm sharing will continue as many more crosses are made among breeding programs than can be fully evaluated (i.e. my crosses are evaluated in Nebraska, but could have utility elsewhere if they were evaluated). Similarly, germplasm developed in other programs could be evaluated in Nebraska for utility. As greenhouses are some of the most capital intensive and high maintenance expenditures that universities make, it would be useful to reduce our reliance on greenhouses and more effectively share early generation germplasm. Bulks that segregated for red and white seed types were advanced to the F_3 nursery and planted with the 1997 F_2s bulks for combine harvest.

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

The triticale nurseries this year were average. Sidney trials were very good, but the Lincoln trials were partially damaged by winterkill and blowing. Visual selection was used to select early generation lines and head rows for advancement.

The key to improved triticale varieties remains access to improved triticale germplasm and efforts continue to increase germplasm diversity. Triticales with high grain and forage yield potential are available and may be useful as a feed grain or forage crop. Triticale research has replaced our research on feed wheat.

1996 Triticale Results:

VARIETY	Lincoln	Sidney	Avg.	Rank
		bu/a*		
PRESTO	33.49	63.07	48.280	25
NE90T413	44.73	69.73	57.230	8
NE91T425	46.83	58.37	52.600	17

NE90T404	44.42	62.52	53.470	14
TSW250783	42.38	91.37	66.875	1
NE90T406	41.38	54.64	48.010	27
NE92T422	53.66	65.49	59.575	5
NE94T417	36.14	72.63	54.385	12
NE95T451	32.92	66.45	49.685	22
NEWCALE	25.47	59.78	42.625	30
NE94T403	32.06	67.93	49.995	20
NE94T406	38.16	61.68	49.920	21
NE94T407	41.47	65.05	53.260	15
NE94T408	31.43	60.87	46.150	28
NE94T410	31.20	71.13	51.165	19
NE94T411	29.62	66.73	48.175	26
NE94T413	29.33	68.59	48.960	23
NE94T415	46.96	60.55	53.755	13
NE94T416	43.16	71.98	57.570	7
TRICAL	39.69	46.71	43.200	29
UGO	34.77	77.24	56.005	10
NE95T409	33.45	63.73	48.590	24
NE95T418	35.92	75.91	55.915	11
NE95T423	47.21	73.77	60.490	4
NE95T424	40.34	81.85	61.095	3
NE95T426	45.12	81.54	63.330	2
NE95T427	42.31	73.26	57.785	6
NE95T431	38.61	66.54	52.575	18
NE95T436	45.90	68.10	57.000	9
ARAPAHOE	36.90	68.32	52.610	16
GRAND MEAN	38.83	67.85	53.340	
CV	17.73	9.08		
LSD	9.40	8.41		

* using a 60 lbs/bu for easy comparison to winter wheat yields. The actual standard for triticale is a 48 lbs/bu.

Some of the lower yielding lines are excellent forage lines, hence yield is not the main criterion for selection in triticale. It is interesting to note the highest yielding named line, UGO, is only tenth and that Arapahoe ranked 16th. Progress can be made in triticale.

1995 Triticale Results:

					Yield (bu/a)*		
ENTRY	HD	Height	rank	Variety	Linc.	Sidney	Avg.
1	33	56.00	27	NE91T401	29.01	69.50	49.255
2	32	53.00	29	NE91T410	36.57	58.26	47.415
3	32	54.00	30	NE91T409	38.35	55.83	47.090
4	30	54.00	16	PRESTO	40.50	72.12	56.310
5	30	55.00	3	NE90T413	46.45	77.41	61.930
6	30	56.00	31	NE90T405	32.30	60.88	46.590
7	31	61.00	2	NE91T425	46.60	80.29	63.445
8	30	57.00	8	NE90T404	47.24	72.62	59.930
9	34	49.00	4	TSW250783	49.55	73.99	61.770
10	28	55.00	6	NE90T406	46.53	74.86	60.695
11	28	52.00	33	NEWCALE	42.45	46.26	44.355
12	39	52.00	34	TRICAL	29.66	57.15	43.405
13	35	48.00	35	ARAPAHOE	17.46	56.53	36.995
14	28	55.00	21	NE92T402	43.40	59.67	51.535
15	33	54.00	26	NE92T414	21.74	77.05	49.395

16	33	52.00	17	NE92T422	37.29	74.78	56.035
17	30	49.00	20	CHD 786	38.40	69.66	54.030
18	27	48.00	25	NE94T401	45.56	53.66	49.610
19	30	51.00	11	NE94T403	49.86	66.31	58.085
20	33	54.00	23	NE94T404	30.42	69.01	49.715
21	28	57.00	28	NE94T405	31.18	67.20	49.190
22	28	57.00	5	NE94T406	48.64	74.30	61.470
23	28	55.00	9	NE94T407	47.38	71.72	59.550
24	28	55.00	15	NE94T408	40.09	72.54	56.315
25	28	57.00	19	NE94T409	33.43	74.88	54.155
26	32	57.00	18	NE94T410	31.80	77.17	54.485
27	32	54.00	10	NE94T411	45.06	73.23	59.145
28	27	55.00	24	NE94T412	33.16	66.21	49.685
29	32	54.00	13	NE94T413	35.59	77.35	56.470
30	28	49.00	32	NE94T414	36.06	55.80	45.930
31	28	50.00	14	NE94T415	38.55	74.19	56.370
32	35	58.00	1	NE94T416	34.83	94.90	64.865
33	31	53.00	12	NE94T417	31.55	81.86	56.705
34	31	54.00	22	NE94T418	25.76	75.39	50.575
35	34	48.00	7	UGO	33.53	87.44	60.485
		53.00	0	GRAND MEAN	37.60	70.00	53.800
		6.00	0	CV	14.69	16.78	
		7.00	0	LSD	7.78	16.56	

The results from 1994 are as follows and are noteworthy for how different the grain yield ranks are between 1994 and 1995.

1994:

	Yield (bu/a)			Rank
	Linc.	Sidney	Avg.	
NE91T401	38.94	51.95	45.445	10
NE91T410	43.76	63.20	53.480	1
NE91T409	40.18	48.73	44.455	14
PRESTO	29.36	60.78	45.070	11
NE90T413	38.83	56.78	47.805	7
NE90T405	35.80	50.00	42.900	20
NE91T425	29.19	65.13	47.160	8
TSW250783	41.14	64.58	52.860	2
NE90T406	33.43	53.95	43.690	15
NEWCALE	32.59	50.18	41.385	25
TRICAL	52.75	44.88	48.815	4
ARAPAHOE	35.61	61.35	48.480	5
NE92T402	35.11	58.38	46.745	9
NE92T414	37.69	48.20	42.945	19
NE92T422	29.15	66.93	48.040	6
CHD 786	35.38	62.98	49.180	3
SIOUXLAND	24.87	61.95	43.410	18
GWT88-16	28.20	51.88	40.040	29
NE88T419	27.05	54.55	40.800	27
NE90T404	33.56	53.40	43.480	17
NE88T213	30.55	48.58	39.565	30
NE88T229	29.44	45.88	37.660	31
NE88T233	30.75	52.08	41.415	24
LAD285	29.25	57.85	43.550	16
GWT88-12	30.39	58.90	44.645	13
NE77T7	27.29	46.08	36.685	32

RYMIN RYE	36.09	48.85	42.470	21
NE92T413	20.10	42.38	31.240	33
NE92T415	19.05	26.78	22.915	35
NE92T418	25.23	54.90	40.065	28
NE92T419	29.43	53.05	41.240	26
NE92T420	28.10	55.25	41.675	23
NE92T421	18.32	41.45	29.885	34
OAC89-6	30.77	59.03	44.900	12
TAM200	31.26	52.38	41.820	22

10. Wheat Transformation and Tissue Culture Studies

Due to a successful grant writing efforts (both within the university and for nationally competitive grants; approximate funding is $1,500,000 over three years), a team of scientists (Dr. A. Mitra, Dr. J. van Etten, Dr. R. French, Dr. P. Staswick, Dr. J. Morris, Dr. T. Elthon, Dr. P. Blum, and Dr. Baenziger) at the University of Nebraska has developed a major effort on wheat and soybean transformation. In wheat, the key goals for transformation will be disease and stress (mainly heat) resistance. As part of this effort Dr. A. Mitra and I were able to hire Ms. Shirley Sato, formerly with Monsanto, who has almost twenty years of experience in plant tissue culture and transformation. We have also looked at optimizing the culture conditions for the transformation of Bobwhite, the main wheat used in transformation, surveyed our winter wheat germplasm to see if there are lines that may be equally useful in wheat transformation as Bobwhite, preliminary indications are that there may be one wheat, and have transformed triticale (work done by Dr. Jan Rybczynski, a Fulbright visiting professor, and Mr. Kim Kyung-moon). Bobwhite is a soft, white, spring wheat which has the advantage of not having a vernalization requirement, but is totally unadapted to hard red winter wheat production. Mr. Kamil Haliloglu continues his research on the best size of anther derived embryoids for regeneration of haploid plants and how best to transform haploid plants.

11. Chromosome Substitution Lines

This research is predominantly supported by nationally competitive grants. Mr. Mohammed Maroof Shah completed the field evaluations of the recombinant Cheyenne (CNN)-Wichita (WI) chromosome 3A lines (a WI chromosome shown to increase yield by 15% in the CNN background). Fifty Wichita-Cheyenne recombinant chromosome 3A lines in Cheyenne background [CNN(R3A)] were evaluated in a multi-location field trials in the 1993-1994, 1994-1995, and 1995-1996 seasons. Our preliminary results indicate significant differences among the recombinant chromosome lines for grain yield, 1000 kernel weight, plant height, and anthesis date. Non-significant differences were identified for kernel/spike and tiller/m^{-2}. Significant genotype by environment interactions were detected for kernel/spike and tiller/m^{-2} which explains why the lines were non-significant for these traits. Distinctive classes (e.g. bimodality) were found for anthesis date which indicates a single gene controls anthesis date, but none of the other agronomic traits could be similarly classified. In general, all of the early lines were similar to WI for plant height, and most of the later lines were similar to Cheyenne in plant height, however two later lines were shorter which may indicate a crossover between linked genes for anthesis date and plant height. The other traits seem to be predominantly independent of anthesis date. This result is important because one hypothesis for the multiple traits affected by 3A was that the gene(s) for earliness had pleiotropic effects on grain yield and seed weight (Berke et al. 1992a). Our data indicated that this does not appear to be the case.

The evaluation of the F_1 hybrids between substitution lines and the recurrent parent was completed and the manuscript accepted for publication. The purpose of this study was to determine if the quantitative trait loci (QTL) on 3A and 6A exhibited additive or dominant gene action which could result in heterosis, because these kinds of gene action cannot be studied with chromosome substitution or recombinant lines due to their homozygosity. The hybrids of CNN(WI3A) x CNN, CNN(WI6A) x CNN, WI(CNN3A) x WI, and WI(CNN6A) x WI were made in cooperation with Agripro Seeds, Inc. Six hybrids, four parental substitution lines, and, to monitor any effects of seed source differences, seed of CNN and WI produced in Lincoln and Colorado were grown in a randomized complete block design with two replications at two locations for two years. Our results showed that the previously reported deleterious effects of WI(CNN3A) and WI(CNN6A) relative to WI, and the beneficial effects of CNN(WI3A) and CNN(WI6A) lines relative to CNN, were generally repeated in these environments. Three of the four hybrids were not significantly different from the midparent value for all of the measured traits, which indicates additive gene action. Some hybrids were also not significantly different from one parent which indicated the possibility of dominant gene action. Midparent heterosis was found for grain yield in one hybrid, which indicates dominant gene action for one trait.

A future goal of this research is to screen for polymorphic molecular markers on the 3A and 6A chromosomes so that we can map the . The screening has been initiated in cooperation with Dr. Kulvinder Gill, a recently hired molecular cytogeneticist at the University of Nebraska, and Dr. Yang Yen, a biochemical cytogeneticist at South Dakota State University. Preliminary results indicate polymorphic markers can be found. A grant to support this research was submitted to the USDA-CREES National Research Initiative.

12. <u>Effect of 1A/1R on Agronomic Performance</u>

Previously, Dr. Benjamin Moreno-Sevilla, now with North Dakota State University, had shown that lines containing 1B/1R from the cross Siouxland x Ram were 9% higher yielding than lines with 1B or lines heterogeneous for 1B/1R, but that 1B/1R and 1B lines derived from the heterogeneous cultivar Rawhide (a variety containing 1B and 1B/1R plants) were not different for grain yield. The 1A/1R translocation has similarly been reported to enhance grain yield. A replicated study conducted by Mr. Eduardo Espitia-Rangel, a graduate student, using Nekota (a heterogeneous variety for 1A and 1A/1R) and a seed increase of Niobrara (a heterogeneous variety for 1A and 1A/1R) for future replicated studies have been initiated to determine if 1A/1R has beneficial effects for yield. So far, 1A/1R in the Nekota background has no yield benefit. Dr. R. A. Graybosch (USDA-ARS) is helping identify which lines contain the rye translocation.

13. <u>Non-red Grain Wheat</u>

In the past, efforts have concentrated exclusively on hard red winter wheat. With the potential Far East market and domestic whole white wheat bread market, efforts will increase for hard white wheat development, mainly in Dr. C. J. Peterson's program. A small effort will continue in developing purple and blue wheats for unique markets. Purple is the historical color for feed quality wheats. However, in our program we have identified a high yielding purple, softer wheat. It is currently being tested by one commercial company and in our western Nebraska state variety trials. A clearly identified (marked) soft wheat may have utility for organic or conventionally grown soft wheat production in non-traditional production areas. A blue wheat may have potential for blue wheat flour tortillas similar to blue corn tortillas. Blue wheat can also be used as a marker for natural and induced outcrossing, and potentially as way of determining the level of stress in a field (the blue color forms late in the seed development and stress may end kernel development before the blue color is completed).

14. <u>Wheat Streak Mosaic Virus Research</u>

Work continues on the resistance in M08, a line identified in our program, and with Dr. Joe Martin, Kansas State University at Hays, Kansas and his co-workers who have developed the germplasm with the first real resistance/tolerance to wheat streak mosaic virus. In greenhouse (Lincoln, NE) and field (at Hays, KS) trials, the source of resistance continues to appear to be promising. Dr. K. Gill has agreed to cytologically analyze M08 and its derivatives so we can gain a better understanding of this potential new source of resistance. M08 is a doubled haploid plant developed from a triticale by wheat cross by Prof. Hu Han who used anther culture to create the doubled haploid line. The M08 source of resistance and the Kansas source of resistance continue to be rapidly transferred to Nebraska germplasm. Dr. Roy French continues to provide invaluable inoculum and virus expertise.

15. Considerations on Nursery Sites

Efforts continue to develop better analytical methods for data analysis. The addition of field trend analyses has already proven itself to be beneficial for analyzing wheat data. The next project is to develop planting designs that better measure spatial variation in unreplicated or fewer replication designs. The augmented design used for the multilocation observation nursery is an example of improved experimental designs which will continue with further modifications (done in collaboration with Dr. W. Stroup and Dr. D. Mulitze of Agronomix, Inc.). A second approach will be to use AMMI models for multiple location evaluations. In theory, they can be used to analyze very efficiently experiments with two replications at multiple locations. The nearest neighbor approaches need to have three replications to be useful.

With karnal bunt being found in the United States, the decision was to move all testing sites under Dr. Baenziger's leadership back onto publicly held land. We returned to Clay Center and to Alliance in 1996 for testing purposes. It is our hope that once more is known about karnal bunt that the southcentral site will again use a sustainable farm to increase our linkages with these emerging farming groups.

16. Global Change Research

One of the new areas that the project hopes to become involved in is global change scenarios. A large, interdisciplinary effort involving climatologists, crop physiologists and production specialists, cereal chemists, biometricians, and plant breeders has been formed. In the future it is expected that plant pathologists and entomologists will be involved as emerging diseases and insect pests will become greater problems with the global change. The goal of this group will be to develop experimental techniques that will allow us to predict what may occur under various global change scenarios (e.g. global warming, elevated CO_2, etc.) and to identify germplasm that may ameliorate these changes. Too often plant breeding is reactive and not sufficiently proactive. With the twelve year time frame that it takes to release a variety, wheat breeding programs need to be as cognizant as possible of future changes. While this may seem too future oriented, it should be recognized that with the variable climate of Nebraska, many of the possible scenarios occur annually in one or another part of Nebraska so the real effort will be to develop a integrated team that will understand wheat production at the ecosystem level. Grants to fund this research were submitted to the National Institute for Global Environmental Change (NIGEC) and USDA-CSREES National Research Initiative.

IV. GREENHOUSE RESEARCH

The F_1 wheat populations were grown only in the Lincoln Greenhouses to avoid possible losses to winterkilling. Over 600 F_1 populations were grown. This is higher than normal and translates to over 650 F_2 plots including checks planted in 1996-1997. An additional 600+ wheat crosses were made for breeding purposes including improving the genetic male sterile population (first planted in 1990). Some crosses were made for genetic studies. In the triticale program, over 70 crosses were made.

V. PROPRIETARY RESEARCH

With the advent of plant biotechnology and hybrid wheat, the necessity and desirability of interacting with commercial has increased. In 1996, the University of Nebraska signed its first agreement to allow a commercial hybrid wheat company to access one of its lines as a hybrid parent. Over 250 unreleased experimental lines were sent to a hybrid wheat company for evaluation as potential future hybrid wheat parents. It is expected that a research and development fee will be assessed for hybrid parent use and that any fees returned to the University will be shared with the financial supporters of the research efforts. In the first agreement, 20% of the fees will be given to the Nebraska Wheat Board in recognition of their ongoing and significant support for the program. To the best of our knowledge, this is the first and only public program that shares its research and development income with its financial supporters.

We are currently negotiating with a herbicide-based company for access to their herbicide tolerant wheat germplasm. This germplasm is potentially quite useful as the herbicides have residual activity and control most grassy weeds (i.e. jointed goat grass, downy brome, cheat grass). Herbicide tolerance will also allow greater flexibility for cropping rotations and will involve our dryland cropping specialists, particularly Dr. Drew Lyon.

With the current level of private sector investments in research, additional public-private interactions are to be expected. A key goal will be to develop working relationships that benefit the producer, the customer, and the public good.

VI. ALLIED RESEARCH

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

The program also depends on interactions and collaborations with the Wheat Board, Nebraska Wheat Growers Association, regional advisory boards, Foundation Seeds Division, Nebraska Crop Improvement Association, the milling and baking industry, and other interested groups and individuals. The Nebraska Wheat Quality Laboratory cooperates closely with the Wheat Quality Council and baked the large scale cooperator samples. 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.

Summary

A below average crop was harvested in 1996 with production estimated at 73.1 million bushels from 2.15 million harvested acres with a state average yield of 34 bu/a. Winterkilling, blowing, and early drought stress was found in many parts of the state. The main diseases were leaf and stem rust in the southeast and southcentral part of Nebraska and soilborne mosaic virus in the southeast part of Nebraska. Insects (Russian wheat aphid and Hessian fly) were minor.

Arapahoe was the most widely grown wheat in Nebraska in 1996. Rawhide and Vista seem to be slowly decreasing in acreage. Due to a dry fall, tall wheats increased in popularity which may explain the reduction in Vista acreage. Alliance continued to have excellent yields and Niobrara and Nekota, released in 1995, and Pronghorn, released in 1996, had a good years.

One new cultivar is in the process of being released. Windstar (formerly NE90625) is an increase of a hard red winter wheat F_3-derived line from the cross TX79A2729//Caldwell/ Brule field sel # 6/3/Siouxland. Windstar is an awned, white-glumed cultivar. Its field appearance is most similar to Rawhide and Siouxland. The canopy is moderately open and upright. The flag leaf is erect and twisted at boot stage. The foliage is blue-green, with a waxy bloom at anthesis. The leaf is pubescent. The spike is tapering in shape, moderately long to long, and middense. Under some environmental conditions, the spike may have a clavate shape same as was seen in Rawhide and Centura. The glume is short to midlong and narrow to midwide, and the glume shoulder is sloping to square. The beak is moderately short to medium with an acuminate tip. The spike is held erect to inclined at maturity and the glumes and straw have a golden color. Kernels are red colored, hard textured, and ovate. The kernel has no collar, rounded cheeks, midsize germ, midsize brush of medium length, and a narrow and shallow crease. Windstar is a taller, semidwarf wheat with medium to late maturity. It is 1 day later than Arapahoe, 3 days later than Alliance, and 3 days later than Pronghorn. Windstar has a short coleoptile similar to Alliance, and shorter than Arapahoe and Pronghorn. Windstar is one inch shorter than Arapahoe, two inches shorter than Pronghorn, similar in height to Niobrara and Rawhide, and four inches taller than Vista. Windstar has moderately strong straw strength; better than Scout 66, Pronghorn, Alliance, Niobrara, and Arapahoe, and is similar to Rawhide. Windstar has exhibited moderate resistance to stem rust (contains Sr6 and Sr24) and moderate susceptibility to leaf rust (Lr24) and wheat streak mosaic virus. It is susceptible to the Russian wheat aphid and the Great Plains biotype of Hessian fly and to soilborne mosaic virus. The winterhardiness of Windstar is comparable to other winter wheat cultivars adapted and commonly grown in Nebraska and South Dakota. Windstar tends to have a slightly lower test weight, similar to Alliance, Niobrara, and Vista, but less than Pronghorn. The recommended growing area for Windstar, based on current information, is the dryland wheat production areas of the Panhandle of Nebraska and western South Dakota. Using western Nebraska data from the Nebraska Fall Sown Cereal Variety Trials from 1994, 1995, and 1996 (15 environments), Windstar (52.7 bu/a) was one bu/a lower yielding than Alliance, similar to Niobrara and Vista, and four bu/a higher yielding than Arapahoe and Pronghorn. In five years of testing in the advanced trials in Nebraska (24 environments), Windstar (52.8 bu/a) was similar to Alliance; 1 bu/a higher yielding than Redland, 2 bu/a higher yielding than Vista and Niobrara; 3 bu/a higher yielding than Pronghorn; and 4 bu/a higher yielding than Arapahoe and Siouxland; 6 bu/a higher yielding than TAM107; and 9 bu/a higher yielding than Buckskin. Windstar was grown in the Northern Regional Performance Nursery in 1993 and 1994. Of the 11 entries grown in the same years, Windstar was the highest yielding line (26 environments). The main advantage that Windstar has when compared to other available wheat varieties is its consistent high yield performance in dryland production. On the basis of its pedigree, Windstar would be a complementary wheat to every variety currently grown in Nebraska and South Dakota with the exception of Siouxland. The overall milling and baking quality properties of Windstar would be considered as acceptable.

Basic research to improve breeding efficiency continued in: 1. wheat tissue culture and transformation, 2. recombinant and reciprocal chromosome substitution line, 3. improving testing sites and data analysis, 4. global climate change, and 5. developing feed grain or forage triticales. Regional efforts and cooperation with commercial companies will continue to increase.

Support from the Wheat Board, Foundation Seeds Division, and the Institute for Agriculture and Natural Resources is gratefully acknowledged as it is only through their generous contributions that the wheat breeding and experimental line testing efforts are possible.