IMPROVING WHEAT VARIETIES FOR NEBRASKA

1994 STATE BREEDING AND QUALITY EVALUATION REPORT

Report to the

NEBRASKA WHEAT DEVELOPMENT, UTILIZATION AND MARKETING BOARD

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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 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 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 1994 NEBRASKA WHEAT CROP

1. Growing Conditions

As opposed to previous years, the state wheat crop though variable had a more "normal" season. The estimated production was 71.4 million bushels from 2.1 million harvested acres with a state average yield of 34.0 bu/a. This is a slightly lower average yield than last year (35 bu/a) and would have to be considered less than should be expected in an average production year. Winterkilling was minimal throughout the state and winter tender lines such as TAM 200 and Arlin survived with no damage. Actually, virtually all of the winter barley (a crop with less winterhardiness than wheat) survived well throughout the state where it was not damaged by wind. As compared to the previous two years, this growing season would have to be considered as being cooler in the fall and early spring, followed by warmer than normal temperatures with less moisture. The general effect was the season was earlier, drier, and warmer. Wind damage was significant in western Nebraska and along drought and heat were the main limitations to wheat production. Insects (Russian wheat aphid and Hessian fly) and diseases (viruses and rusts) were minor. For example, stem rust came in late or was not present and caused little loss. Leaf rust was present, but cause only an estimated 0.5% loss.

The difference between this season and the previous two is quite noticeable. The last two years favored lines that come out of the winter late, flower and mature late, and are semi-dwarf lines. This year early lines were favored, such as Karl 92, or lines with good stress tolerance, such as Alliance or the new wheats varieties, Nekota and Niobrara (described in detail later).

2. Diseases

Foliar diseases are highly dependent on moisture, hence foliar diseases were minor on the wheat crop. The races of leaf rust continue to evolve. Previously resistant lines, such as Karl, have lost most or all of their resistance. More leaf rust is being seen on lines with Lr3 and Lr16 which are present in Arapahoe, Redland, and Vista. These lines are so popular that the increasing frequency of leaf rust races with virulence on these varieties may represent they are being sampled more often. 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.

3. Insects

In general, most insects pests were at low levels on wheat in 1994. Russian wheat aphid damage was insignificant and required little spraying. This contrasts strikingly with Colorado where over 250,000 acres were sprayed. Chinch bugs and Hessian fly were generally minor, though low levels of fall infestation of Hessian fly were found in many areas of southern Nebraska. 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 wheat production for Nebraska is 71,400,000 bushels from 2,100,000 harvested acres. The average yield was 34 bushels/acre. The poorest crop in last five years was the 1989 crop when the wheat yield for Nebraska was 27 bu/a from 2,050,000 acres for a total production of 55,350,000 bushels.

Planted and harvested acres increased as a result of farm programs. Quality determinations by Inchape Labs (Doty) were as follows:

Wheat Protein Content (12% moisture basis)

Nebraska	1994 %	1993 %	Five Year Average %
Northeast	12.9	12.0	12.3
Southeast	12.1	12.1	12.8
Northcentral	13.1	12.1	12.7
Southwest	12.4	11.8	12.7
Panhandle	12.4	11.8	12.3

Generally, higher wheat protein contents were available to the milling and baking industry in 1994 when compared with last year and the five year average.

Quality standards are being impacted by long fermentation processes, such as sponge and dough baking methods. Currently quality considerations of bread crumb grain and texture are paramount in the baking industry. These procedures require stronger gluten proteins (longer dough mixing times and tolerances). Drought and heat stress can reduce mixing time and tolerance which may have reduced the quality of the crop. Of the quality characteristics that growers are paid for, test weight was the most significant trait adversely affected by diseases, drought, frost, or cool growing conditions.

5. Cultivar Distribution

A variety survey was done in 1994, however, no variety survey was done in 1992 so that year is missing. Arapahoe has been quickly accepted by the growers and continues to be the most widely grown variety (33.6% of the state) in 1994. 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. The acreage of Siouxland and TAM wheats continued to drop which will improve the reputation of Nebraska as a provider of quality wheat grain. 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 71.5% of the state acreage. Private varieties occupied 19.1% of the state acreage.

NEBRASKA--WHEAT VARIETIES
ESTIMATED PERCENTAGES PLANTED TO EACH VARIETY, 1989-1995

	Percent					
Variety	1989	1990	1991	1993	1994	1995
Brule	12.0	9.4	5.4	3.1	1.4	1.4
Siouxland	20.5	18.7	14.5	8.2	6.4	4.0
Centura	12.4	9.6	10.4	8.5	11.1	8.0
Centurk & Centurk 78	4.6	4.4	3.3	1.6	---	1.3
Agripro Thunderbird	7.2	10.7	12.8	12.4	10.0	7.8
Redland	10.0	15.2	14.9	7.9	6.3	4.3
Cody	2.9	2.4	1.8	---	---	---
Buckskin	2.2	1.9	2.2	4.7	5.5	4.0
Scout & Scout 66	2.6	2.2	2.4	2.8	1.6	3.4
Agripro Abilene	1.0	5.5	6.3	6.2	3.0	4.1
All TAM wheats	3.8	6.0	8.0	3.4	2.8	2.5
Arapahoe	---	1.8	8.5	28.6	32.9	33.6
Rawhide	---	---	---	2.1	2.0	1.0
Vista	---	---	---	---	---	4.6
Karl	---	---	---	2.1	3.8	6.9
Agripro Victory	---	---	1.7	1.3	---	1.0
Agripro Tomahawk	---	---	---	1.0	3.9	3.1
Agripro Laredo	---	---	---	---	---	1.2
Other Public Varieties	4.3	4.0	4.3	4.2	6.0	5.9
Other Private Varieties	6.0	3.1	2.0	1.9	3.3	1.9

6. New Cultivars

Two new wheat varieties (Nekota and Niobrara) were released in 1994.

Nekota (P.I. 584997, also known as NE88427) was released to certified wheat producers in 1994. Nekota was developed cooperatively by the South Dakota Agricultural Experiment Station, Nebraska Agricultural Experiment Station and the Northern Plains Area, Agricultural Research Service, U. S. Department of Agriculture. The name was chosen in recognition of Nekota's adaptation to both South Dakota and Nebraska.

Nekota is an increase of a hard red winter wheat F_3-derived line from the cross Bennett/TAM107 which was made in 1982. Nekota was identified in 1988 and tested as NE88427 in Nebraska yield trials starting in 1989, and the Southern Regional Performance Nursery in 1991 and 1992. The current breeder seed originated from a purification program in 1991-1992, 1992-1993, and 1993-1994 designed to remove off-types by roguing.

Nekota, in Nebraska, is a white chaffed, awned, winterhardy, moderately early semidwarf wheat (similar in anthesis date to Alliance, later than TAM107, earlier than Arapahoe) that is 2 inches taller than Vista and 1 inch shorter than Alliance in plant height. Nekota (79 mm) has an intermediately long coleoptile (longer than Alliance (66 mm), similar to TAM107 (80 mm)). It is moderately susceptible to leaf rust, and is susceptible to soilborne and wheat streak mosaic viruses, and Hessian fly. Nekota is heterogeneous for secalins encoded by the Sec-1 locus which is indicative of the Amigo translocation (1A/1R) derived from TAM107. Plants containing the Amigo translocation have been reported as being a non-preferred host for wheat curl mite, the vector of wheat streak mosaic virus. Hence in the field it may have less wheat streak mosaic virus than varieties that do not contain this non-preference trait. It is moderately resistant to stem rust (contains genes Sr6 and is heterogeneous for the Amigo gene). Nekota (58.6 lbs/bu) has good test weight characteristics (superior to Siouxland (57.8 lbs/bu), Redland (56.9 lbs/bu), Arapahoe (57.3 lbs/bu), Vista (57.0 lbs/bu) and Alliance (57.2 lbs/bu)) and winterhardiness. The straw strength of Nekota is adequate (superior to Arapahoe,

but less than Redland).

In three years of testing in the Nebraska Fall Sown Cereal Variety Trials (37 environments), Nekota (53.7 bu/a) was lower yielding than Alliance (54.8 bu/a), but superior to Redland (52.2 bu/a), Rawhide (49.9 bu/a), and Siouxland (48.7 bu/a). In the two years (1991 and 1992) that it was tested in the Southern Regional Performance Nursery, Nekota (3640 bu/a) averaged 8% lower grain yield than TAM107, a broadly adapted cultivar. However, in the northern high plains region of the testing site, Nekota (3080 bu/a) had a slightly higher yield than TAM107 (3040 bu/a). The recommended growing region for Nekota needs further refinement, but would include southeast, southcentral, and southwest Nebraska in the absence of leaf rust or if fungicide applications were used to control this disease. It also has done well in South Dakota. Nekota would be considered genetically similar to TAM 107, Bennett, and Niobrara.

Nekota's performance in the South Dakota Crops Performance Testing Variety Trial (1993, 1994; 22 environments) has been similar to its performance in Nebraska. Nekota is an early (3 days later than TAM107 and 1 day earlier Alliance) semi-dwarf (1 inch taller than TAM107 and Vista and 1 inch shorter than Alliance) wheat. Nekota had exceptional test weight characteristics (60.8 lbs/bu) and was to superior Abilene (60.4 lbs/bu), Arapahoe (59.3 lbs/bu), Vista (59.1 lbs/bu) and Alliance (58.9 lbs/bu). The yield of Nekota (50.6 bu/a) was slightly less than Alliance (51.4 bu/a), but was superior to Arapahoe (49.7 bu/a), Seward (49.1 bu/a), Vista (48.9 bu/a), and TAM107 (46.7 bu/a).

The milling and baking properties of Nekota were determined using six years of testing by the Nebraska Wheat Quality Laboratory with Arapahoe and Scout 66 as check cultivars. The average wheat and flour protein content of Nekota is lower than Arapahoe but higher than Scout 66. The flour yield is less than Scout 66, but higher than Arapahoe. The dough mixing properties were weaker than Arapahoe and similar to Scout 66. While the baking absorption of Nekota was similar to Arapahoe and less than Scout 66, average loaf volumes were greater than Scout 66 and less than Arapahoe. The external appearance and internal attributes of the baked bread loaf indicated generally acceptable quality characteristics.

The South Dakota Foundation Seed Division, Department of Plant Science, South Dakota State University, and the Nebraska Foundation Seed Division, Department of Agronomy, University of Nebraska-Lincoln will have foundation seed available to qualified certified seed producers in 1994. The seed classes will be breeder, foundation, registered (salable only among crop improvement members) and certified.

Niobrara (P.I. 584996, also known as NE89522) was released to certified wheat producers in 1994. Niobrara was developed cooperatively by the Nebraska Agricultural Experiment Station and the Northern Plains Area, Agricultural Research Service, U. S. Department of Agriculture.

Niobrara is an increase of a hard red winter wheat F_3-derived line from the cross TAM 105*4/Amigo//Brule sel which was made in 1983. Niobrara was identified in 1989 and tested as NE89522 in Nebraska yield trials starting in 1990, and the Northern Regional Performance Nursery in 1993. The current breeder seed originated from a purification program in 1991-1992 and 1992-1993 designed to remove off-types by roguing.

Niobrara is a white chaffed, awned, winterhardy, moderately early semidwarf (two days later than Alliance and two days earlier than Redland) wheat that is 4 inches taller than Vista (29 inches), 1 inches taller than Alliance (32 inches) and similar in height to Redland (33 inches). It is susceptible to Hessian fly and soil borne mosaic virus, and moderately susceptible to leaf rust. In greenhouse tests, it appears to be slightly less tolerant to wheat streak mosaic virus than Redland. It is heterogeneous for secalins encoded by the Sec-1 locus which is indicative of the Amigo translocation (1A/1R). Plants containing the Amigo translocation have been reported as being a non-preferred host for wheat curl mite, the vector of wheat streak mosaic virus. Hence in the field, the line may have both some tolerance to the virus and non-preference to the virus vector. Niobrara is moderately resistant to stem rust (contains genes Sr6 and is heterogeneous for the Amigo gene). Using data from the 1993 and 1994 Nebraska Fall Sown Cereal Variety Trials (26 environments), Niobrara is a lower test weight wheat (56.9 lbs/bu) similar to Alliance (56.8 lbs/bu), slightly superior to Redland (56.7 lbs/bu), but lower than Arapahoe (57.1 lbs/bu), Siouxland (57.7 lbs/bu), and Nekota (58.5

lbs/bu). The straw strength is adequate (superior to Arapahoe, but less than Redland).

Niobrara has had an excellent yield performance record in Nebraska. It was the highest grain yielding line in the Nebraska Fall Sown Cereal Variety Trials State Variety Trial in each year that it was tested (1993 and 1994). The average grain yield was 57.9 bu/a which was superior to Alliance (56.9 bu/a), Vista (55.1 bu/a), Redland (54.8 bu/a) and Siouxland (51.4 bu/a). Niobrara also had the highest average yield of the fifteen lines tested in both 1992 and 1993 in the Uniform Northern Regional Performance Nursery. In the four years (1991-1994) that Niobrara (47.2 bu/a) has been tested in the Nebraska Intrastate Nursery, only Alliance (48.5 bu/a) had a superior yield record. For comparison, the grain yield of Redland, Vista, Arapahoe, and TAM107 were 45.7, 45.2, 44.6, and 42.2 bu/a, respectively. The primary growing region is southwest Nebraska, northern Nebraska, and the panhandle where its winterhardiness, plant height, tolerance for cooler weather, and disease resistance are most effective. On the basis of parentage, Niobrara would be considered genetically similar to Brule, Redland, Arapahoe, Vista, and Nekota.

The milling and baking properties of Niobrara were determined using five years of testing by the Nebraska Wheat Quality Laboratory with Arapahoe and Scout 66 as check cultivars. The average wheat and flour protein content of Niobrara is lower than Arapahoe and Scout 66. The flour yield is less than Scout 66, but higher than Arapahoe. The dough mixing properties were similar to Arapahoe and stronger than Scout 66. While the baking absorption of Niobrara was less than Arapahoe and Scout 66, average loaf volumes were greater than the two check cultivars. The external appearance and internal attributes of the baked bread loaf indicated generally acceptable quality characteristics.

The Nebraska Foundation Seed Division, Department of Agronomy, University of Nebraska-Lincoln will have foundation seed available to qualified certified seed producers in 1994. The seed classes will be breeder, foundation, and certified. The decision to have a registered seed class has not been made. Niobrara 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

Three experimental wheats are in large scale increase for possible release in 1995. They are NE88584 (Centura/Dawn//Colt sib), NE90479 (KS83H2510 (H11)/Brule 83 Composite), and NE90524 (Brule field sel. #5/5/Bez1/3/Ctk78//Arthur/Ctk78/4/Cody).

NE88584 is a tall, long coleoptile wheat with adequate straw strength. It has very good test weight characteristics and moderate sized kernels. It would be considered as a medium early wheat. It has good stem rust resistance (contains Sr6) and moderate resistance to leaf rust. It is susceptible to Hessian fly, wheat streak mosaic virus, wheat soilborne mosaic virus, and Russian wheat aphid. It has been tested for two years in the state variety trials and the target area for best adaptation would be western Nebraska and Wyoming. In this area, its yield is similar to Buckskin, but NE88584 has better disease resistance. The overall milling and baking quality would be considered as above average.

NE90479 is a moderately tall, intermediate coleoptile length wheat (similar to TAM107) with average straw strength. It has large kernels and very good test weight characteristics. It would be considered a medium maturity wheat. It is moderately resistant to stem rust and wheat soilborne mosaic virus. It is moderately susceptible to leaf rust, Hessian fly, and wheat streak mosaic virus. It is susceptible to Russian wheat aphid. In its first year of testing in the state variety trial, it seems to do particularly well in eastern and southeastern Nebraska. This is the first wheat in many years with good wheat soilborne mosaic virus resistance, which will help its adaptation in southeastern and southcentral Nebraska which would be its targeted area. The overall milling and baking quality would be considered as well above average. This is a good quality wheat. NE90479 probably has the highest likelihood of release in 1995 of the three mentioned here.

NE90524 is a moderately tall, long coleoptile wheat with average straw strength. It has average sized kernels and good test weight characteristics. It would be considered a medium

maturity wheat. It is moderately resistant to stem rust (contains Sr6) and moderately susceptible to leaf rust. It is susceptible to wheat streak mosaic virus, wheat soilborne mosaic virus, Hessian fly, and Russian wheat aphid. In its first year of testing in the state variety trial, it seemed to have an average performance throughout the state. Hence it will need an additional year of testing to determine it target area, should it be released. The overall milling and baking quality would be considered as average for Nebraska released varieties.

The following lines are under small scale increase with earliest possible release in 1996: NE90625 (TX79a2729//Caldwell/ Brule field sel # 6/3/Siouxland), NE91631 (NE82761/Brule 84 sel.), NE91648 (NE82671/2/Ctk78*2/Lov 13), and NE91651 (NE82671 /2/Ctk78*2/Lov 13).

NE90524 (Brule field sel. #5/5/Bez1/3/Ctk78//Arthur /Ctk78/4/Cody)is a moderately tall, long coleoptile wheat with average straw strength. It has average sized kernels and good test weight characteristics. It would be considered a medium maturity wheat. It is moderately resistant to stem rust (contains Sr6) and moderately susceptible to leaf rust. It is susceptible to wheat streak mosaic virus, wheat soilborne mosaic virus, Hessian fly, and Russian wheat aphid. The overall milling and baking quality would be considered as average for Nebraska released varieties.

With the release of new varieties 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-three entries were included in some or all of the locations in the Fall Sown Small Grain Variety Tests in 1994. Fourteen dryland, one irrigated, and one ecofallow nurseries were harvested for yield data. The top ten lines for dryland production 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

In 1992 the top ten lines for dryland production were:

Entry	Av. Yield bu/a	Entry	Av. Yield bu/a
Alliance	49.25	Arapahoe	43.15
Nekota	48.18	NE87612	42.75
Vista	47.55	TAM107	42.63

Redland	45.97	NE83404	42.44
N87V106	44.24	Yuma	42.31

Of the lines tested in all locations, 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. Hybrids continue to do well in these tests, but may not be economical for many growers. Not all lines were tested in all locations, hence other high yielding lines may be overlooked when using state averages.

3. Irrigated Wheat Trials

The irrigated wheat nursery was at Scottsbluff. This trial is planted in cooperation with Dr. D. Baltensperger. The irrigated trial attempts to simulate the majority of irrigated wheat planting conditions: planted late as would be the case after a summer crop harvest. The results from 1994 and 1992 are:

1992 Results at Sidney		1994 Results at Scottsbluff	
NE88427	42 bu/a	Yuma	87 bu/a
Vista	39	Karl	86
TAM200	38	Laredo	85
Arapahoe	37	Rawhide	85
Agripro Sierra	37	Abilene	84
Hybrid F2#2	36	N87V106	84
Redland	36	Colt	83

Efforts continue to identify lines that may have potential under irrigation, but not necessarily under dryland conditions.

4. Nebraska Intrastate Nursery

The Nebraska Intrastate Nursery (NIN) was seeded at eight locations (Mead is a single replicate for winterhardiness notes and Beatrice is a single replication for observation) and all locations were harvested. The nurseries at Mead (single replication), Beatrice (due to too much field variation), and McCook (severe drought) are not reported.

The NIN data follow:

	Yield (bu/a)						Rank
VARIETY	Linc.	Holstein	N.Plat.	Sidney	Hemm.	Average	
ARAPAHOE	62.563	63.097	50.090	75.267	59.613	62.126	27
BUCKSKIN	55.371	56.531	42.074	68.583	53.950	55.302	58
NE88584	63.020	66.107	51.867	63.383	54.188	59.713	45
Alliance	59.298	64.051	56.699	80.950	64.138	65.027	5
Niobrara	65.336	64.945	54.866	70.967	61.100	63.443	15
NE90476*	64.202	70.670	52.825	73.350	66.113	65.432	4
NE90479*	62.020	62.635	51.499	70.017	62.800	61.794	31
NE90524	64.818	66.498	54.110	73.650	59.813	63.778	11
CHEYENNE	56.140	52.460	47.054	62.567	62.325	56.109	56
VISTA	60.322	66.591	55.361	75.433	60.138	63.569	13
KARL92	68.323	68.665	51.202	76.900	72.038	67.426	1
NE90625	59.080	57.174	62.314	77.483	59.663	63.143	20
NE91515	67.796	62.983	47.117	81.150	60.675	63.944	10

NE91518	63.809	67.698	54.786	79.417	63.900	65.922	2
NE91631*	60.602	63.186	50.383	84.233	58.688	63.418	16
RAWHIDE	64.644	65.736	52.749	72.833	60.913	63.375	19
REDLAND	58.181	61.571	50.667	67.917	62.913	60.250	38
NE91648*	64.565	64.621	52.090	82.350	58.700	64.465	7
NE91651*	63.056	63.193	46.440	77.100	65.538	63.065	21
NE92456	61.063	68.939	49.774	72.117	60.913	62.561	23
NE92458*	67.072	62.021	47.661	77.483	62.800	63.407	17
NE92466	57.407	58.605	48.644	76.250	59.950	60.171	40
NE92477	61.056	64.600	52.364	61.783	60.015	59.964	43
SCOUT66	62.197	54.312	48.351	78.117	53.525	59.300	46
SIOUXLAND	56.128	58.589	53.531	79.600	64.938	62.557	24
NE92522*	65.408	62.558	61.119	74.283	64.500	65.574	3
NE92603	63.190	59.030	51.638	66.133	60.550	60.108	41
NE92608	68.684	64.275	56.692	71.233	60.925	64.362	9
NE92614*	66.316	61.099	51.624	64.450	60.688	60.835	35
NE92628*	63.360	58.448	52.153	68.617	66.600	61.836	30
TAM107	61.935	57.147	50.551	80.800	62.300	62.547	25
NE92646*	65.190	61.448	58.104	70.550	62.300	63.518	14
NE92652	62.466	63.103	53.215	76.567	69.163	64.903	6
NE92662*	63.740	63.542	54.702	70.133	64.900	63.403	18
VBF0168	64.138	61.563	43.258	65.017	64.963	59.788	44
CENTURA	63.898	60.469	53.314	73.167	59.300	62.030	28
HBF0263	62.645	61.931	56.684	74.950	62.250	63.692	12
N87V106	67.684	64.369	46.663	71.850	60.988	62.311	26
Nekota	59.829	60.608	41.156	65.633	61.263	57.698	50
NE89526	60.576	61.636	50.684	74.717	65.313	62.585	22
NE90411	58.076	64.690	50.507	67.067	64.575	60.983	33
NE90616	60.856	62.683	45.807	72.917	60.150	60.483	36
NE91509	58.521	67.661	47.938	72.467	59.738	61.265	32
NE91527	61.387	59.912	52.512	75.583	60.475	61.974	29
NE91542	54.634	63.784	48.506	72.033	65.863	60.964	34
NE91562	61.930	61.357	45.405	67.567	65.925	60.437	37
NE91608	61.598	59.083	45.882	58.633	60.875	57.214	52
NE91635	59.033	59.336	50.479	74.017	58.088	60.191	39
ROUGHRIDER	45.882	54.105	43.122	78.200	57.563	55.774	57
NE91691	62.195	56.202	39.771	69.233	54.763	56.433	55
NE92412	61.803	61.559	48.593	59.267	63.050	58.854	48
NE92462	57.189	56.364	46.345	57.767	56.863	54.906	59
NE92513	61.129	59.275	54.580	53.733	56.750	57.093	53
NE92538	58.948	57.257	48.756	68.900	66.500	60.072	42
NE92557	54.926	59.703	54.925	67.500	55.813	58.573	49
NE92578	62.072	58.028	49.212	70.533	55.325	59.034	47
NE92605	64.647	70.610	54.429	70.067	62.113	64.373	8
NE92637	61.596	54.336	42.009	70.450	58.200	57.318	51
TAM200	63.125	60.207	33.351	59.767	54.588	54.208	60
NE92644	53.297	57.518	48.008	64.017	61.063	56.781	54
GRAND MEAN	61.500	61.673	50.270	71.279	61.227		
CV	8.631	6.892	7.399	11.013	7.479		
LSD	7.407	5.932	5.190	12.693	6.390		

* Advanced to USDA Regional Nurseries for further testing.

In general all of the trials that were replicated and not severely damaged by heat and drought had remarkably similar and good yields which meant that it was difficult to select for moderately adverse conditions. Holstein, a site near Clay Center, was an excellent site and

was part of our efforts to use representative field conditions to test our lines. Hemmingford is similarly a representative field of a producer. Part of the nursery at Lincoln was affected by take-all and part of the nursery at North Platte was affected by Cephalosporium stripe.

The Nebraska Wheat Quality Lab analyzed for milling and baking characteristics 38 advanced experimental lines and check varieties from the 1993 NIN which were retained for further testing in the 1994 NIN. One line, NE90479, scored very good for external appearance and excellent for crumb grain and texture. The loaf volume was 965cc. Bread baked from thirteen other lines from the NIN scored good to very good: NE88584, NE90411, NE90476, NE90524, NE90616, NE91515, NE91527, NE91542, NE91562, NE91608, NE91631, NE91651, and NE91691. Interestingly, the only lines that were rated as poor for one or more quality characteristics were Siouxland and TAM107.

The Nebraska Wheat Quality Lab analyzed for milling and baking characteristics 27 advanced experimental lines and check varieties from the 1993 Triplicate Nursery which were advanced for further testing in the 1994 NIN. The Nebraska Wheat Quality Lab evaluated nine samples as having notable promise for end-use processing. Breads baked from NE92462, NE92466, NE92477, NE92513, NE92557, NE92614, NE92637, NE92644, and NE92662 have loaf volumes in excess of 900cc. Additionally, the external appearance and internal characteristics of these experimental lines were scored good to very good. One line, NE92538, was rated as having sticky dough handling properties after mixing. Bread made from another line, NE92605, had a poor external appearance.

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). A number of high yielding lines were identified that exceeded the checks. TAM107 had the highest yield and ranked 9th.

The yield data are:

	Yield (bu/a)							
VARIETY	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
NE93451	64.690	59.900	52.078	65.900	63.169	54.731	19	22.650

NE93452	70.605	69.387	49.908	68.817	60.125	55.886	11	16.475
NE93462	66.448	63.570	51.704	64.283	63.795	55.090	16	20.740
NE93473	62.314	60.346	48.119	74.767	63.523	54.915	17	20.420
NE93477	69.401	57.808	48.039	63.367	59.803	53.616	33	23.275
NE93496	64.558	57.723	42.302	71.700	67.455	54.175	28	21.310
NE93522	65.100	56.287	48.199	69.267	61.450	54.481	22	26.585
NE93535	68.984	59.098	49.838	66.600	60.175	53.995	29	19.275
NE93536	71.445	64.055	53.131	66.800	62.607	56.736	7	22.375
NE93549	68.176	57.819	48.537	75.067	63.673	54.567	21	14.130
NE93554	74.663	69.891	54.148	76.433	61.980	60.249	1	24.380
NE93597	64.423	61.017	54.858	73.150	64.116	55.669	13	16.450
NE93598	62.965	60.875	52.543	71.617	61.882	53.842	31	13.170
NE93613	67.562	63.200	58.332	76.533	60.762	57.552	5	18.920
NE93618	65.665	61.852	53.111	74.400	58.569	55.733	12	20.800
NE93649	60.708	60.376	55.244	70.850	61.034	54.469	23	18.600
NE93669	72.568	67.531	53.511	72.167	58.603	57.830	2	22.600
N93L005	62.518	61.513	50.999	66.267	64.695	52.815	38	10.900
Tomahawk	64.958	61.935	52.225	66.950	60.223	55.094	15	24.275
NE93414	65.052	59.443	47.997	62.383	65.780	54.405	24	25.775
NE93416	59.733	59.711	45.913	57.800	56.507	50.082	54	20.825
NE93437	65.471	56.550	49.917	63.250	61.379	52.425	42	17.980
NE93441	62.711	56.359	52.424	53.817	56.144	50.893	52	23.900
NE93453	60.669	62.567	52.884	64.133	62.380	54.212	27	22.640
NE93455	65.283	62.934	44.006	70.417	57.349	52.087	44	12.530
Arapahoe	66.623	58.254	50.992	70.417	61.986	53.876	30	14.985
NE93456	57.820	50.103	53.387	55.183	61.111	49.362	57	18.565
NE93467	66.041	61.629	51.722	66.383	56.841	52.982	36	15.275
NE93469	64.967	58.046	55.228	67.767	59.295	53.771	32	17.325
NE93474	67.218	58.958	55.199	71.317	57.704	54.334	25	15.605
NE93475	65.995	52.067	48.947	63.783	57.302	51.401	50	20.310
NE93476	62.699	60.173	53.419	61.100	60.438	53.547	34	23.455
NE93516	67.003	55.706	50.040	61.450	56.505	52.221	43	22.620
NE93526	67.389	55.175	50.611	63.567	55.932	51.729	48	17.700
Redland	65.196	59.827	51.352	72.333	63.030	54.796	18	17.035
NE93544	64.810	55.617	46.590	66.517	62.541	52.782	39	20.615
NE93546	65.593	58.944	45.414	67.033	59.258	52.729	40	20.130
NE93551	63.028	64.760	47.788	73.200	65.098	55.492	14	19.080
NE93552	60.555	60.063	52.388	76.650	61.869	54.628	20	16.240
NE93573	61.810	63.212	44.012	62.117	58.457	51.773	47	21.030
NE93574	65.588	59.885	49.313	73.617	56.404	53.160	35	14.155
NE93599	68.406	61.439	48.298	69.933	53.681	52.865	37	15.430
Scout66	61.426	47.772	46.014	57.533	55.775	46.811	59	12.345
NE93627	60.843	56.705	50.085	70.833	55.578	50.843	53	11.015
NE93639	57.211	46.086	47.520	63.700	59.241	47.209	58	9.495
NE93643	59.233	55.430	49.482	67.267	53.076	49.561	55	12.880
NE93645	62.162	50.216	56.508	66.550	56.004	51.046	51	14.835
NE93646	58.331	56.901	50.421	70.983	56.876	51.510	49	15.545
NE93658	56.606	57.718	43.819	67.383	57.029	49.456	56	14.180
NE93663	61.809	61.706	52.313	68.450	58.134	54.280	26	23.265
NE93672	66.897	59.299	48.267	59.217	57.354	51.817	46	19.870
NE93676	61.008	59.765	48.394	63.517	61.140	51.913	45	17.655
N93L020	57.758	48.507	38.611	57.083	47.738	42.898	60	7.690
N93L244	61.472	55.919	54.232	67.300	59.805	52.653	41	17.190
Tam107	71.490	57.730	52.568	73.400	65.484	56.349	9	17.420
GRAND MEAN	64.654	59.164	50.524	67.668	60.167			18.646
CV	6.990	6.095	7.109	8.003	4.977			25.316

LSD	7.308	5.831	5.808	8.757	4.842		9.446

* Not included in the state average due to low yield and potential field variation.

Twenty-two lines were advanced to the Nebraska Intrastate Nursery which is normal for advancement from this nursery. All lines were thoroughly analyzed for milling and baking quality including an optimized bake test prior to advancement. The Nebraska Wheat Quality Laboratory milled and baked 61 composite wheat samples form the Duplicate Nursery. Wheat protein contents of these samples from the Duplicate Nursery ranged from 11.4% to 15.0% (14% moisture basis). One wheat sample, NE93455 was rated as having poor milling characteristics. Breads baked from fifteen experimental lines were rated as very good in one or more evaluation criteria: NE93451, NE93453, NE93456, NE93475, NE93476, NE93526, NE93549, NE93554, NE93574, NE93597, NE93613, NE93627, NE93645, NE93672, and NE93676. Loaves baked from NE93435, NE93516, NE93544, NE93551, NE93599, NE93618, NE93658, NE93663, and NE93697 were rated as poor for one or more quality factors.

In 1993, the top ten lines were:

	Yield (bu/a)						Rank
VARIETY	Linc.	ClayC.	N.Plat.	McCook	Hemm.	Average	
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

In 1992, the top ten lines were:

	Yield (bu/a)				
VARIETY	Linc.	N.P.NA	HemNA	AVG.	RANK
REDLAND	72.20	72.50	55.57	66.757	1
NE91648	66.43	72.60	61.15	66.727	2
NE91631	64.13	70.33	65.71	66.723	3
NE91564	68.10	72.67	58.07	66.280	4
NE91632	63.53	70.68	62.56	65.590	5
NE91571	65.87	70.94	58.21	65.007	6
NE91405	57.20	79.06	57.01	64.423	7
NE91635	60.33	74.69	55.81	63.610	8
NE91562	63.83	68.40	58.45	63.560	9
NE91525	58.23	75.54	56.11	63.293	10

6. Regional Nurseries

The Southern Regional Performance Nursery (SRPN) was harvested at Lincoln, Holstein, North Platte, Sidney, and Hemmingford. Yields were as follows:

Variety	Yield (bu/a)						Rank
	Linc.	Holst.	N. Plat.	Sidney	Hemm.	St. Avg.	
Kharkof	44.293	41.694	37.850	50.425	51.335	45.119	45
Scout 66	53.530	52.690	48.000	55.150	53.063	52.487	35
TAM107	57.030	64.170	48.483	52.800	58.034	56.103	28
OK88767-11	61.203	56.249	39.600	43.275	59.876	52.041	37
OK88767-02	57.727	50.028	27.717	53.025	60.623	49.824	42
OK90604	57.937	55.984	40.683	43.075	60.095	51.555	39
OK90649	57.310	55.999	35.333	46.875	56.885	50.480	40
OK91783	53.953	62.193	43.733	43.475	57.621	52.195	36
HBZ374C	56.877	59.421	48.333	59.300	55.217	55.830	30
TX90D927	49.840	56.231	45.200	43.400	55.228	49.980	41
TX89A71	65.753	66.128	52.527	63.900	61.603	61.982	7
TX91V493	48.853	56.248	39.600	39.950	59.718	48.874	43
TX90V8410	55.397	54.009	41.117	55.400	62.915	53.768	33
TX90V7911	53.793	54.248	38.700	32.625	49.328	45.739	44
TX91V3308	55.803	55.414	44.417	48.225	54.385	51.649	38
TX89A7141	58.800	59.445	52.267	67.575	61.313	59.880	14
TX90V6313	56.403	65.705	38.567	53.825	57.764	54.453	32
TX92V4135	62.260	61.997	33.683	49.175	60.826	53.588	34
HBE0726-1	56.320	55.889	42.233	73.500	63.259	58.240	19
CO880169	51.450	61.807	42.917	68.775	63.026	57.595	23
CO880210	53.680	62.565	45.633	57.725	62.721	56.465	27
CO910927	49.047	62.799	46.833	57.325	63.310	55.863	29
KS92PO59E	60.247	65.123	53.433	70.100	65.035	62.788	5
KS92PO263-137	59.717	65.538	59.433	64.675	60.847	62.042	6
KS92PO363-134	65.267	64.153	52.033	56.150	61.662	59.853	15
KS92PO425-155	64.183	67.601	47.817	60.475	63.301	60.675	11
KS84063-9-39-3	57.560	65.824	49.700	66.425	64.309	60.764	9
KS93U206	55.840	64.817	51.633	65.225	59.893	59.482	16
NE87V106	58.433	59.640	49.783	54.925	64.533	57.463	25
NE90479	65.937	63.541	51.450	60.475	63.878	61.056	8
NE90524	61.723	57.866	56.283	68.775	59.118	60.753	10
NE91608	57.497	60.358	49.000	46.250	62.955	55.212	31
NE91635	57.157	65.136	54.250	64.700	61.029	60.454	12
NE91651	59.310	56.919	50.483	58.875	62.810	57.679	21
XH1520	60.823	64.689	49.800	65.025	60.302	60.128	13
XH1529	61.460	59.618	36.750	59.175	71.104	57.621	22
XH1689	69.470	74.093	62.500	64.950	69.433	68.089	2
XH1693	71.453	78.318	58.983	72.975	69.677	70.281	1
XH1706	61.647	73.842	61.083	70.800	71.436	67.762	3
WI89-273-13	70.783	65.922	42.083	45.700	62.397	57.377	26
WI89-189-14	69.747	69.646	44.767	43.525	59.938	57.525	24
T4731	66.943	62.071	50.400	54.950	61.969	59.267	18
T4732	64.700	68.000	57.600	46.150	60.635	59.417	17
T81	60.773	70.489	53.200	69.475	65.056	63.799	4
T83	66.670	66.350	44.633	44.475	66.679	57.761	20
GRAND MEAN	59.213	61.788	47.123	56.290	61.248		
CV	11.379	7.658	9.931	16.677	5.936		
LSD	10.933	7.679	7.593	18.919	5.901		

Obviously the hybrids performed well under these conditions.

The Northern Regional Performance Nursery (NRPN) also was harvested at Lincoln, North Platte, Sidney, and Hemmingford. Yield were as follows:

Variety	Yield (bu/a)					Rank
	Linc.	N. Plat.	Sidney	Hemm.	St. Avg.	
Kharkof	53.046	45.533	47.986	55.283	48.855	28
Roughrider	47.961	46.600	56.745	58.783	50.435	25
Abilene	56.136	62.900	63.753	58.617	60.930	8
SD89119	58.962	54.867	57.005	57.600	56.945	19
SD89333	61.006	59.627	63.019	55.083	61.217	7
SD89153	54.135	51.033	66.483	54.883	57.217	18
SD89180	56.605	53.583	59.625	55.467	56.604	20
SD89186	53.953	56.917	61.676	56.283	57.515	16
SD89205	57.190	61.933	69.637	51.750	62.920	4
HBC197F	59.013	53.383	60.946	54.517	57.781	14
ND8933	49.713	52.217	59.293	43.167	53.741	22
ND8955	53.806	56.833	61.136	51.850	57.258	17
ND8889	57.494	53.300	62.108	51.267	57.634	15
ND90109	52.523	47.717	57.973	56.617	52.738	24
ND8974	52.072	47.817	49.748	51.950	49.879	27
ND9043	49.675	43.117	40.316	47.617	44.369	29
ND9064	52.866	51.617	56.172	48.067	53.552	23
NE90625	61.073	66.250	65.417	54.433	64.247	2
NE90616	56.203	55.917	66.335	51.817	59.485	10
NE91562	57.872	54.117	66.113	53.333	59.367	11
NE91631	54.266	54.883	70.925	49.433	60.025	9
NE91648	66.789	59.083	64.699	53.133	63.524	3
XNH1564	65.647	60.150	61.905	50.167	62.567	6
XNH1727	60.542	58.600	73.688	49.033	64.277	1
XNH1772	64.392	62.583	61.732	51.467	62.902	5
XNH-1	53.119	56.167	64.354	50.300	57.880	13
XNH-2	60.005	52.583	62.171	49.217	58.253	12
IDO426	49.245	38.000	63.488	52.800	50.244	26
IDO355HW	58.683	45.033	65.154	54.283	56.290	21
GRAND MEAN	56.345	53.874	61.366	52.697		
CV	8.885	9.753	6.881	9.644		
LSD	8.192	8.594	6.909	8.313		

In this nursery, the hybrids continue to perform well, but also the later Nebraska experimental lines did well.

7. Multiple-Location Observation Nursery

All six replications (locations) of this nursery were harvested, however, many nurseries suffered from spatial variation (e.g. a blow-out that affected part of Sidney or Cephalosporium stripe which affected part of North Platte). In addition, the lines were generally lack-luster due their being selected at Lincoln in 1993 which was severely damaged by rain and delayed harvest. Of the 290 lines including checks and 30 higher protein lines from Dr. C. J. Peterson's germplasm program that were evaluated, 55 (11 from Dr. Peterson's program) were advanced to the NTN. To avoid future problems with an unreplicated nursery, an improved augmented design was developed for this nursery in which Arapahoe was used as a check every 15 plots and at every 60 plots Arapahoe, Karl 92, and TAM107 were used as checks. Hence every plot can be compared to Arapahoe.

8. Early Generation Nurseries

a. Single-plot Observation Nursery

Fourteen hundred and ninety lines including checks were evaluated in 1994. Of this group over 450 were selected for further testing. From this group 273 lines were selected for further testing. The cooperative test became larger due to 30 lines from Dr. Peterson, 3 lines from Cargill, and 110 lines from Dr. Don McVey, stem and leaf rust cooperator. The lines were initially selected on the basis of yield and then sent to the Nebraska Wheat Quality Laboratory. The quality analyses were completed before planting, hence only high yielding, high quality lines were advanced.

b. Headrow Nursery

Over 43,000 headrows were planted at Mead. The headrows generally survived the winter and were infected with stem rust which greatly aided in selecting against susceptible types. The early planted headrows were quite good, but the later planted headrows were severely thinned by the winter and blowing. The poor seed quality in 1993 also contributed to the poor head row growth. After selecting for seed quality 1460 lines including checks were selected for further testing. This is a normal level of selection.

a. F_3 bulk hybrids

The F_3 bulk hybrid nursery contained 589 bulks and check plots and were planted at Mead and Sidney. At both locations, the bulks looked extremely vigorous. All F_3 bulks were be planted at Mead and Sidney to provide better information on how segregating bulks do in the diverse environments and to provide a back-up site in case of inclement weather. The number of F_3 bulks is near the optimal size. Most bulks survived the winter and were satisfactory for selection. Over 42,000 head rows were selected for fall planting. 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 692 bulks and check plots. These bulks survived the winter. In order to rush harvest, they were harvested by combine (hence will include some mixed seed). Harvesting four rows gave ample seed for planting the F_3 bulk nursery in 1995 at Mead and at Sidney.

9. Winter Triticale Nursery

The triticale nurseries this year were average. Sidney trials were very good, but the Lincoln trials were damaged by heavy rainfall directly after planting. 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 yield potential are available and may be useful as a feed grain or forage crop. Triticale research replaced our research on feed wheat.

Variety	Yield (bu/a)*			Rank
	Linc.	Sidney	St. 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

* based on a 60 lbs/bu test weight.

10. Doubled Haploid and Wheat Tissue Culture Studies

Improving our ability to make doubled haploids was part of the research of Ms. Vicki Gustafson who attempted to develop wheat isolated microspore cultures. Though she was successful in regenerating over 100 plants from these cultures, the system was highly variable and not repeatable.

As part of the overall tissue culture effort, Ms. Carla Wildhagen, in cooperation with Dr. Amit Mitra, attempted to develop methods for transferring genes from any organism to wheat. Her experiments indicated that the number of days on culture of the immature embryo did not affect embryo/callus viability after electroporation. In addition, a number of electroporated embryos survived on selection medium. However, once the selection pressure was removed and plants regenerated, no transformed plants were identified. This may be due to untransformed cells having greater regeneration capacity than transformed cell in the absence of selection against them. As no untransformed tissues survived on the selection medium, it is doubtful that the lines surviving the selection were escapes.

11. Chromosome Substitution Lines

A series of lines in which single pairs of chromosomes were transferred from Cheyenne, the most important ancestor in the Nebraska Wheat Improvement efforts, to Wichita, an important wheat from Kansas, and vice versa have been developed by Dr. M. R. Morris. Previous research showed that chromosomes 3A and 6A have major effects on agronomic performance (can reduce or enhance yield by 20%). Current efforts by Dr. Yang Yen are concentrating on developing recombinant chromosome lines which will be used to determine how many genes on the identified chromosomes affect yield. The first replicated field experiment was harvested in 1994. Additional field tests are underway. In cooperation with Agripro

Biosciences, hybrids of the chromosome substitution lines have been made to identify chromosomal heterosis. The data from these trials are now being analyzed.

12. Heat Stress on Grain Filling

Research by Mr. Masrizal continued with Dr. E. Millet, of the Weizmann Institute of Science in Israel, and Dr. M. Clegg, of the University of Nebraska to study the effect of short term heat stress on grain filling in wheat. Our current procedures involve heating the spike for 96 hours with 12 hours of 38 C and 12 hours of 25 C. Ambient conditions are 26 C day and 20 C night in the greenhouse. We have tested eighteen genotypes using this system. There is little genetic variation for stress tolerance, however a significant genotype x treatment interaction was identified indicating there may be small differences among lines for heat tolerance. Our field experiments used a very low-technology method of providing heat stress by placing glass jars over the spikes. In sunlight, temperatures rise in the jars, thus providing a heat stress. The most startling effect was that by heat treating wheat spikes 10 days after anthesis, the seed development can be greatly affecting (almost completely stopped). More subtle changes occur when the heat stress is given to spike 14 and 18 days after anthesis. The seed from the field experiments are being cleaned for quality analyses. The field experiments were repeated in 1994 and are currently being analyzed.

13. Effect of 1B/1R on Agronomic Performance

Dr. Benjamin Moreno-Sevilla, previously a graduate student and now project leader, 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. Rawhide, a recent release, is heterogeneous for 1B and 1B/1R. 1B/1R and 1B lines were extracted from Rawhide and grown in three environments in Nebraska in 1992 and in 1993. No difference was found for yield between the 1B and 1B/1R lines in 1992 and in 1993 trials. Though the quality of the Rawhide 1B line is better than the Rawhide 1B/1R, the 1B/1R lines tended to have "acceptable" quality (at least, better than Siouxland). A similar replicated study conducted by Mr. Eduardo Espitia-Rangel, a graduate student, using Nekota and a seed increase of Niobrara for a future replicated study has been initiated to determine if 1A/1R has beneficial effects for yield. Dr. R. A. Graybosch (USDA-ARS) is helping identify which lines contain the rye translocation.

14. Non-red Grain Wheat

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. For example 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).

15. Wheat Streak Mosaic Virus Research

Ms. Jill Petrisko has initiated research with Dr. Roy French (USDA-ARS) to determine if races exist within the wheat streak mosaic virus. Preliminary field data indicated considerable variability within and among fields. In cooperation with Drs. Hein, Baltensperger, and Martin (KSU), she is also developing an improved field assay for tolerance under Nebraska growing conditions. Her first effort on the field screen was largely unsuccessful. Dr. Martin and his co-workers have developed some germplasm with the first real resistance/tolerance to wheat streak mosaic virus. The gene continues to be rapidly transferred to Nebraska germplasm.

16. 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 partially replicated designs. The augmented design used for the multilocation observation nursery is an example of improved experimental designs. This research is done in collaboration with Dr. W. Stroup of the Biometry Department. In addition, due to heavy deer grazing at Clay Center and the location being north of the main wheat growing region, the yield trials were moved to Holstein with great success. In 1994-1995, the southcentral site is now on a sustainable farm to increase our linkages with these emerging farming groups.

18. Environmental Effects on Plant Height

With the continued interest in taller wheats for western Nebraska, Dr. Necdet Budak, a graduate student, completed his research on how to better understand factors determining plant height. He tried to find lines that are not too tall in eastern Nebraska, but are tall in western Nebraska. He has determined that tall wheats tend to be tall in all locations (e.g. Buckskin) or to be tall in eastern Nebraska (where they are generally too tall) and rapidly become shorter in western Nebraska (where the tall wheats are needed). The latter group is well represented by most modern tall wheat experimental lines. The semi-dwarf wheats can be short in every environment (e.g. Vista) or moderately tall in eastern Nebraska and retain their height in western Nebraska (e.g Arapahoe). Hence it may be possible to select for tall semi-dwarfs that retain their height under stress conditions. NE90625, an advanced experimental line, has this attribute in addition to being very wind (blow-out) resistant. Research with Dr. Al Weiss determined relatively crude climatic measurement, plant heights under optimal conditions, and pre-existing wheat growth models can be used effectively to model wheat plant height.

IV. GREENHOUSE RESEARCH

The F_1 wheat populations were grown only in the Lincoln Greenhouses to avoid possible losses to winterkilling. Over 710 F_1 populations were grown. This is higher than normal and translates to 696 F_2 plots including checks planted in 1994-1995. An additional 598 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 40 crosses were made.

V. 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. These large scale samples include two lines (NE88427 and Alliance) from the cooperative USDA/University of Nebraska breeding program and are among the most important quality tests for an experimental line or recently released variety. 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 1994 with production estimated at 71.4 million bushels from 2.1 million harvested acres with a state average yield of 34.0 bu/a. Winterkilling was minimal. As compared to the previous two years, this growing season would have to be considered as being cooler in the fall and early spring, followed by warmer than normal temperatures with less moisture. The general effect was the season is earlier, drier, and warmer. Wind damage was significant in western Nebraska and with drought and heat were the main limitations to wheat production. Insects (Russian wheat aphid and Hessian fly) and diseases (viruses and rusts) were minor.

Arapahoe was the most widely grown wheat in Nebraska in 1994. Rawhide, released in 1990, is slowly decreasing in acreage, while Vista, released in 1992, is increasing in popularity. Alliance, released in 1994, had a good first year.

Nekota (P.I. 584997, also known as NE88427) was released to certified wheat producers in 1994. Nekota is an increase of a hard red winter wheat F_3-derived line from the cross Bennett/TAM107 which was made in 1982. Nekota, in Nebraska, is a white chaffed, awned, winterhardy, moderately early semi-dwarf wheat with an intermediately long coleoptile.It is moderately susceptible to leaf rust, and is susceptible to soilborne and wheat streak mosaic viruses, and Hessian fly. Nekota is heterogeneous for secalins encoded by the Sec-1 locus which is indicative of the Amigo translocation (1A/1R) derived from TAM107. Plants containing the Amigo translocation have been reported as being a non-preferred host for wheat curl mite, the vector of wheat streak mosaic virus. Hence in the field it may have less wheat streak mosaic virus than varieties that do not contain this non-preference trait. It is moderately resistant to stem rust (contains genes Sr6 and is heterogeneous for the Amigo gene). Nekota has good yield and test weight characteristics, winterhardiness, and adequate straw strength and end-use quality. The recommended growing region for Nekota needs further refinement, but would include southeast, southcentral, and southwest Nebraska in the absence of leaf rust or if fungicide applications were used to control this disease. It also has done well in South Dakota. Nekota would be considered genetically similar to TAM 107, Bennett, and Niobrara.

Niobrara (P.I. 584996, also known as NE89522) was released to certified wheat producers in 1994. Niobrara is an increase of a hard red winter wheat F_3-derived line from the cross TAM 105*4/Amigo//Brule sel which was made in 1983. Niobrara is a white chaffed, awned, winterhardy, moderately early semidwarf with a intermediately long coleoptile. It is susceptible to Hessian fly and soil borne mosaic virus, and moderately susceptible to leaf rust. In greenhouse tests, it appears to be slightly less tolerant to wheat streak mosaic virus than Redland. It is heterogeneous for secalins encoded by the Sec-1 locus which is indicative of the Amigo translocation (1A/1R). Plants containing the Amigo translocation have been reported as being a non-preferred host for wheat curl mite, the vector of wheat streak mosaic virus. Hence in the field, the line may have both some tolerance to the virus and non-preference to the virus vector. Niobrara is moderately resistant to stem rust (contains genes Sr6 and is heterogeneous for the Amigo gene). Niobrara has very good yield characteristics; and average test weights, straw strength, and winterhardiness; and adequate end-use quality. On the basis of parentage, Niobrara would be considered genetically similar to Brule, Redland, Arapahoe, Vista, and Nekota.

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. a better understanding of plant height to select tall wheats, 5. identifying lines with tolerance to short term heat stress, and 6. the molecular biology of wheat streak mosaic virus and how to select lines with resistance to this pathogen. The winter triticale program will continue and be positioned as a feed grain or forage alternative to winter wheat and barley for growers needing small grain feeds or forage.

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.