Winter Wheat Breeding and Genetics Program
Annual Progress Report
Colorado State University – Fall 2000

Winter wheat breeding at Colorado State University (CSU) is a cooperative effort involving breeding program personnel, research and extension staff at CSU and elsewhere, and farmer-cooperators who donate their time and land to assist with field testing activities. The primary goals of the program are to: a) develop improved wheat varieties and germplasm adapted for the diverse production conditions in Colorado and the west central Great Plains and b) conduct research that contributes either directly or indirectly to improved winter wheat production and end-use quality. The following report summarizes the various activities of the breeding program and main areas of progress during the 1999-2000 season.

I. Site Conditions

In 1999-2000, the breeding program conducted field trials at four main locations in eastern Colorado (Walsh, Burlington, Akron, and Julesburg) in addition to the main site located at the ARDEC research facility near Fort Collins. Excellent stands and fall growth were achieved at each of these locations. Russian wheat aphid (RWA) populations were noted at several trial locations, but the wet conditions in April reduced populations dramatically. At both Walsh and Burlington, severe bird cherry-oat aphid and greenbug infestation occurred in late fall and significant barley yellow dwarf virus (BYDV) was observed by late May. At Akron, a damaging freeze in the early morning hours of May 13 affected yields of some of the earlier-maturing materials. At Julesburg, conditions were very dry from late October right up until the time of harvest. Each of these locations suffered from significant drought and high temperature stress from May until harvest. Aside from the BYDV, very little disease pressure (e.g., root rot, leaf rust, etc.) was noted in the breeding nurseries.

In cooperation with the CSU Variety Testing Program, under the direction of Dr. Jerry Johnson, varieties and experimental lines were also tested at six dryland trial locations (Bennett, Cheyenne Wells, Genoa, Lamar, Orchard, Sheridan Lake) and two irrigated trial locations in eastern Colorado (Haxtun and Rocky Ford). Overall conditions at each of the dryland locations was very much similar to the four breeding locations (e.g., good stands with adequate moisture until late April), except that the severity of the freeze damage was much greater at Bennett and was very closely associated with maturity (e.g., estimated 80% loss in some varieties, later entries performing much better). The plots at Orchard were not harvested (due to very severe drought, insect, and freeze damage) while data from Sheridan Lake were not reported due to problems associated with herbicide carryover. Conditions at irrigated trial locations were generally good, with lower than expected yields at Rocky Ford (due to hot, dry winds in April and May) and very high yields at Haxtun where the trial was planted adjacent to the Maximum Economic Yield (MEY) trial under the direction of Dr. Johnson.

II. Variety and Germplasm Development

Several field, laboratory, and greenhouse-based activities contribute to the overall breeding effort. The core of this effort can be likened to a “pipeline” with materials entering the pipeline at the beginning (e.g., new crosses), materials leaving the pipeline at the end (e.g., new varieties or germplasm releases) and materials at all possible stages in between subject to various testing, screening, and selection activities. In addition to this central pipeline, we are currently involved in several supplementary activities or areas of emphasis that will also be described.

A. State Variety Trials

In 1999-2000, the former High Moisture Variety Trial (HMVT, primarily northeastern Colorado locations) and Low Moisture Variety Trial (LMVT, primarily southeastern Colorado locations) were merged into a common dryland trial called the Uniform Variety Performance Trial (UVPT). The main rationale for this change was that private breeding companies (primarily ***HybriTech***, ***Agripro***, and ***Cargill-Goertzen***) had recently tended to enter materials only into the HMVT, deliberately bypassing the typically lower-yielding LMVT locations and leaving inadequate space in the HMVT for experimental lines from our breeding program. The result of this was that experimental lines selected from the Advanced Yield Nursery (AYN) were only entered into the LMVT where data loss was much more common. For example, between 1990-1999, only 2.3 LMVT locations per year were harvested, the remainder being lost due to hail, drought, or other uncontrollable factors. In the 2000 UVPT, with planting at 10 dryland locations, the number of entries increased (from about 45 to 60) with the number of experimental lines (32 total) much greater than in years past.

Grain yield, test weight, and agronomic data from the UVPT are shown in Table 1. Despite the very stressful production conditions and the resulting “compression” of entry yields into an unusually narrow range, very reliable data were obtained from seven UVPT locations. One location (Bennett, data not shown) was severely confounded by the effects of the May freeze and the close association with maturity (late entries performed better).

Several experimental lines that performed well in the 1999 dryland trials, particularly CO960603 (a Russian wheat aphid-susceptible ***Akron*/*Yuma*** line), performed very poorly in 2000 due largely to their medium-late maturity and the effects of the drought and high temperatures. One hard white line, CO940610, continued to perform extremely well but was discarded due to overall unacceptable baking quality. On a more positive note, several experimental lines (highlighted in **bold** in Table 1) performed very well and were retained for further testing in both the dryland (UVPT) and irrigated trials (IVPT) and, in certain instances, Foundation or Breeder seed increase. The most promising of these lines are the following:

CO940611 – hard white sister selection of ***Trego***, RWA-susceptible, very high test weight, good milling and baking quality. On Foundation seed increase (in Colorado) for potential release in fall 2001.

CO980894 – hard red herbicide-tolerant derivative of ***TAM 110***, white-chaffed, RWA-susceptible, good test weight, acceptable milling and baking quality. On Foundation seed increase (in Yuma, Arizona) for potential release in fall 2001.

CO980889 – hard red herbicide-tolerant derivative of ***TAM 110***, red-chaffed, RWA-susceptible, acceptable milling and baking quality. On Foundation seed increase (in Yuma, Arizona) for potential release in fall 2001.

CO950043 – hard red line derived from a cross with 50% ***Lamar*** parentage, high yield potential, very good stress tolerance, different RWA resistance than available varieties, marginal baking quality characteristics. On breeder seed increase (in Yuma, Arizona) for potential release in fall 2002.

CO970498 – hard red ***Ogallala*/*Halt*** line, RWA resistant, very good stress tolerance, very good milling and baking quality characteristics. On breeder seed increase (in Yuma, Arizona) for potential release in fall 2002.

CO970547 – hard red ***Ike*/*Halt*** line, RWA resistant, very good stress tolerance, acceptable milling and baking quality characteristics. On breeder seed increase (in Yuma, Arizona) for potential release in fall 2002.

Table 1. Grain yield (bu/acre), test weight (lb/bu), and agronomic and disease reaction ratings from the 2000 UVPT.

Entry	Akron	Burl.	Jules.	Genoa	Walsh	Lamar	Chey.W.	GY Avg.	TW Avg.	FG	BYDV	HD	HT
CO940610	44.9	41.0	38.4	69.7	42.5	29.3	50.8	45.2	57.3	2.4	2.7	139	28
CO970531	39.2	43.4	38.9	60.2	47.3	24.8	47.2	43.0	55.4	2.9	5.0	138	28
CO940611	41.5	42.3	35.1	63.7	43.9	29.7	44.2	42.9	59.3	2.1	4.0	140	28
CO970547	43.6	48.8	45.4	57.0	40.5	23.2	39.7	42.6	57.5	1.7	5.0	138	28
CO950043	31.8	49.4	33.4	62.0	44.6	26.8	49.5	42.5	58.1	2.7	3.0	141	29
Trego	45.7	36.0	30.2	62.9	39.6	33.2	46.3	42.0	59.7	3.6	4.7	142	27
CO970552	38.3	45.2	40.4	55.4	43.2	25.8	45.5	42.0	56.4	2.1	3.3	137	29
XH9806	36.0	41.2	34.6	62.1	39.0	32.8	48.0	42.0	57.3	2.6	4.0	139	27
CO980894	39.2	48.4	36.8	57.1	40.0	23.1	47.4	41.7	57.0	2.4	2.7	137	28
CO970498	35.8	44.9	38.9	53.4	40.6	25.3	50.5	41.3	58.7	2.4	3.7	138	27
QAP 7406	44.5	41.7	32.7	66.1	31.9	26.1	46.0	41.3	57.8	2.9	3.7	139	28
2137	43.0	38.0	31.5	61.4	41.0	26.7	46.0	41.1	56.1	3.3	2.0	142	28
Q 7588	36.9	43.1	34.2	60.5	36.8	27.0	49.2	41.1	56.4	2.5	5.7	142	30
CO980889	39.6	47.4	37.8	57.7	38.9	21.4	42.7	40.8	56.3	2.4	3.3	136	28
Lakin	36.0	39.9	35.5	60.1	38.6	26.2	48.3	40.6	57.2	3.1	2.3	141	28
Alliance	41.2	39.6	36.3	57.6	35.0	27.9	45.5	40.4	56.5	4.8	3.7	139	28
XH7463	39.1	33.5	32.6	63.4	40.0	28.7	45.7	40.4	56.9	2.6	3.3	139	28
Yuma	38.1	36.4	34.8	63.3	40.2	26.8	42.6	40.3	56.8	2.4	5.3	141	27
TAM 110	37.7	47.3	36.3	58.6	35.1	22.3	44.8	40.3	56.7	4.5	2.3	136	29
Venango	34.4	43.5	31.8	63.1	40.1	26.9	42.0	40.3	58.2	2.3	1.7	141	28
Nuplains	39.1	42.1	30.9	56.9	36.6	28.3	46.8	40.1	59.6	3.1	8.3	144	26
CO970919	34.6	42.1	37.6	62.8	36.4	22.4	44.2	40.0	56.4	2.5	2.7	137	28
CO970943	35.0	39.9	35.0	58.3	40.3	24.9	45.3	39.8	56.2	2.3	4.0	137	27
Prairie Red	43.0	38.9	33.2	52.9	39.9	25.0	45.3	39.7	56.9	2.9	4.3	136	27
TAM 107	39.0	38.6	37.9	58.2	39.1	22.4	42.6	39.7	56.9	2.7	3.3	136	27
CO970787	38.9	35.9	30.2	60.4	39.5	31.4	41.2	39.6	55.7	2.5	3.7	142	28
CO980879	33.3	48.8	35.4	53.7	37.8	22.4	44.8	39.5	56.2	3.0	1.3	136	28
CO980890	37.4	46.7	35.1	50.8	40.0	22.3	42.8	39.3	55.6	2.5	4.0	137	29
CO970875	40.5	36.7	30.1	64.5	33.6	26.4	41.7	39.1	56.4	3.2	3.3	141	25
Kalvesta	34.2	35.4	33.6	55.6	36.5	30.6	47.2	39.0	58.7	3.1	3.7	138	27
Enhancer	37.8	39.3	29.8	61.8	36.4	24.0	43.8	39.0	55.0	1.6	1.7	140	30
Stanton	34.5	36.5	28.6	61.8	34.6	28.4	48.4	39.0	58.0	2.5	3.7	141	27
QAP 7510	37.0	36.8	30.7	58.8	35.9	27.7	45.7	39.0	57.5	3.1	1.7	139	26
Cossack	33.1	41.8	32.5	57.9	36.0	25.0	45.7	38.9	58.0	1.4	4.0	144	30
G15048	36.2	34.7	32.8	62.0	33.0	28.0	44.1	38.7	58.6	4.2	6.7	142	26
CO970887	40.1	36.5	30.8	54.7	41.1	25.9	40.1	38.5	56.3	2.4	3.3	141	25
CO980875	34.8	39.8	35.9	49.3	41.5	21.6	46.1	38.4	56.0	3.1	4.7	136	28
CO970773	36.6	38.9	30.4	55.4	37.3	28.4	41.8	38.4	56.6	2.4	6.0	142	28
Akron	38.8	29.8	28.3	67.8	34.4	24.8	43.9	38.3	57.0	2.2	6.7	142	27
XH3207	28.1	40.7	30.7	60.9	34.9	27.4	42.7	37.9	58.0	2.5	7.7	139	27
CO970940	36.9	35.7	31.4	53.5	34.0	26.6	47.0	37.9	56.4	2.1	7.0	142	29
CO970769	35.8	32.2	29.1	61.8	36.7	26.6	42.4	37.8	56.7	2.6	6.3	143	27
Jagger	41.5	34.1	39.4	55.2	28.6	24.1	40.6	37.6	55.8	1.8	4.7	138	28
CO970866	38.6	36.8	30.0	61.7	33.2	24.8	37.5	37.5	57.0	2.0	3.3	139	28
CO960026	40.1	31.5	26.7	63.1	34.8	23.3	40.2	37.1	57.8	2.8	7.3	139	27
CO980881	33.9	38.4	36.4	54.7	34.8	21.5	37.9	36.8	56.2	3.0	4.7	136	27
CO970908	32.0	35.7	33.8	57.0	33.5	23.9	39.5	36.5	55.6	2.9	3.7	139	29
CO970883	39.9	32.0	30.7	53.1	31.4	25.6	41.6	36.3	57.4	1.8	6.7	139	27
Halt	38.3	30.8	31.8	58.2	32.7	21.9	40.1	36.3	56.1	3.6	7.0	138	25
CO970474	29.0	39.9	29.9	53.6	36.1	23.6	40.9	36.1	55.9	2.8	4.0	139	28
Yumar	35.1	32.9	31.2	56.2	32.1	24.6	40.8	36.1	57.2	2.9	6.0	141	26
CO970235	31.8	30.2	29.8	59.0	32.3	25.8	43.7	36.1	57.0	1.4	7.7	143	27
CO970655	32.1	41.0	32.5	52.9	27.2	22.6	39.8	35.4	56.7	1.7	4.0	138	28
CO970901	34.8	31.9	27.4	49.2	34.2	26.4	41.5	35.0	57.4	2.0	4.0	139	28
CO960603	34.3	31.7	25.4	51.4	32.0	22.0	46.8	34.8	56.0	3.5	6.7	142	29
CO960223	27.5	25.0	26.2	54.2	32.5	27.6	42.7	33.7	56.3	1.8	7.7	141	27
CO970812	31.7	25.4	26.5	58.2	27.9	24.8	40.3	33.5	59.1	2.0	9.0	143	30
Prowers 99	29.1	22.3	21.8	53.7	28.9	23.9	36.5	30.9	58.1	2.3	9.0	144	31
Prowers	32.4	22.8	20.9	54.8	25.7	21.7	37.4	30.8	58.2	1.8	9.0	144	31
Wichita	26.1	26.3	27.5	41.7	26.6	19.9	36.4	29.2	58.3	2.4	6.3	141	33

* TW Avg.=test weight average over locations; FG=fall growth potential (1=good, 5=poor); BYDV= barley yellow dwarf virus reaction (1=tolerant, 9=susceptible); HD=days to heading (from Jan. 1); HT=plant height (inches).

Grain yield and test weight data from the irrigated variety Performance Trial (IVPT) are shown in Table 2. As mentioned previously, yields at Haxtun were very good while yields were lower than usual at Rocky Ford (due to hot, dry winds in April and May). One experimental line, CO950043, performed very well at both locations and was the top yielding line based on a two-location average. This line has also done very well in the dryland trials (as mentioned previously) and is currently in both the UVPT and IVPT and under Breeder seed increase for potential release in fall 2002. While this line appears to possess a unique combination of superior dryland and irrigated performance, and carries a new RWA resistance gene, baking quality evaluations have not been very favorable.

Table 2. Grain yield (bu/acre), test weight (lb/bu) from the 2000 IVPT.

Entry	Haxtun	Rocky Ford	GY Avg.	TW Avg.
CO950043	130.6	95.6	113.1	56.3
Venango	129.3	94.2	111.8	56.9
TAM 107	130.0	91.3	110.7	55.0
CO940610	119.5	101.2	110.4	54.6
XH9806 (hybrid)	126.9	92.7	109.8	55.3
XH9801 (hybrid)	135.0	84.3	109.7	55.9
Yuma	133.6	83.7	108.7	54.5
XH3207 (hybrid)	127.5	88.9	108.2	56.8
XH9815 (hybrid)	129.9	85.8	107.9	55.6
Jagger	123.8	86.9	105.3	54.6
XH7463 (hybrid)	126.7	83.0	104.8	55.4
QAP 7406 (hybrid)	130.8	77.0	103.9	55.9
QAP 7510 (hybrid)	125.7	80.2	103.0	56.5
CO940611	120.0	85.7	102.9	56.8
2137	124.2	81.0	102.6	54.1
Enhancer	113.2	87.2	100.2	53.7
CO960603	115.0	84.8	99.9	54.5
Q 7588 (hybrid)	112.2	86.3	99.2	53.7
G15048	120.6	76.4	98.5	57.9
Trego	108.5	88.4	98.5	57.3
Nuplains	107.0	89.3	98.2	56.1
Yumar	119.5	75.0	97.2	52.2
CO960223	104.0	89.2	96.6	53.6
Prairie Red	111.0	82.0	96.5	55.4
Custer	122.5	70.1	96.3	55.5
Wesley	117.2	75.2	96.2	54.4
Kalvesta	106.4	81.5	94.0	56.6
Akron	106.7	74.4	90.6	55.2
Cossack	95.5	77.3	86.4	55.0
CO960026	82.7	74.0	78.4	57.1

Over the last several years, the typical practice of the breeding program has been to enter experimental lines into the irrigated variety trial only after performing well in their first year of testing in the dryland trial. The rationale for this has been that seed supplies were generally insufficient for entry into both trials the first year and the irrigated trial was generally a smaller trial with a focus more toward irrigated variety ***recommendations*** rather than irrigated variety ***development***. For 2001, we have added the Fort Collins ARDEC location as a third “official” IVPT testing site and have included at this location all first-year experimental lines that were entered into the UVPT. We hope that this approach will allow us to gradually enhance our breeding emphasis for irrigated production conditions.

B. Winter Increases in Yuma, Arizona

One significant change in the program in 2000 was the use of a winter nursery environment in Yuma, Arizona, where we conducted: a) Breeder seed increases of two hard white lines, b) Breeder seed increases of six herbicide tolerant lines, c) preliminary seed increases of ***Akron***-RWA backcross lines, and d) preliminary seed increases of herbicide-tolerant doubled haploid materials.

For many years, northern Plains barley and spring wheat breeders have used this “tool” to accelerate their breeding efforts by allowing two generations to be grown in one year (e.g., one in Arizona, one in the northern Plains). While this aspect of acceleration is not possible with winter wheat, and the costs of growing breeding materials in Arizona are not insignificant, the use of this environment presents very definite advantages to our program. In this and coming years, we would hope to continue to use Arizona mainly for simultaneous Breeder seed increase and purification for hard white wheat and Russian wheat aphid resistant lines. The rationale and justification for this approach are as follows:

1) **enhanced seed increase ratio**: Breeding line purification, whether for white kernel color or RWA resistance, is typically done by growing a number of single rows derived from individual head selections (thus called “headrows”) of the line requiring purification. Purification for kernel color involves harvesting headrows separately and visually inspecting the seed prior to compositing while purification for RWA resistance involves RWA screening in the greenhouse and eliminating headrows that show susceptible or mixed reactions. Seed increase from a single headrow in Arizona is roughly ***2-3 times greater*** than typically achieved under irrigation in Fort Collins. Because of this ratio, for a certain amount of Breeder seed desired we are able to grow ***2-3 times fewer*** headrows in Arizona and save field space at ARDEC where significant space limitations currently restrict our program.

2) **hard white wheat isolation**: Because there is always significant potential for outcrossing and mechanical mixtures, and hard red mixtures in hard white varieties are unacceptable above a certain threshold, isolation of hard white Breeder seed increases is absolutely critical. At ARDEC in Fort Collins, space limitations effectively prevent us from isolating breeding materials during increase.

3) **minimal risk of loss**: Increases grown in the desert environment of Arizona are subject to very mild winters (though cool enough to vernalize winter wheat) and very few, if any, thunderstorms or hailstorms. Other production risks, such as viruses, fungal diseases, and insects, are also very minimal.

C. ***Akron***-RWA Backcross Materials

In 1999-2000, 85 ***Akron***-RWA backcross lines, originating from the San Luis Valley increase in summer 1999, were grown in single replication preliminary trials at Akron, Julesburg, and Fort Collins. Grain yield, agronomic, and end-use quality data from these preliminary trials were used as selection criteria for advancement of five lines to the 2001 UVPT in fall 2000. Because these lines are still segregating for RWA resistance, RWA resistance purification is currently being done (in cooperation with Dr. Frank Peairs) utilizing greenhouse RWA screening and the Arizona winter increase as described above. The seed source for the 2001 UVPT (12 pounds required) and the headrow purification (750 headrows for each of five lines) was increase plots grown from ***only 20 grams of seed*** sent to Arizona in fall 1999. Based on performance in the 2001 UVPT, we hope to advance one or two ***Akron***-RWA backcross lines for a second year of testing in the UVPT, simultaneous Foundation seed increase, and potential release in fall 2002. Using the San Luis Valley and Arizona environments, a minimum of two years was cut from the development time required for release of ***Akron***-RWA backcross lines.

D. Herbicide Tolerant Wheat (CLEARFIELD™ WHEAT)

In 1999-2000, 130 wheat x maize doubled haploid lines, originating from the San Luis Valley increase in summer 1999, were grown in single replication preliminary trials at Akron, Julesburg, and Fort Collins. The doubled haploid effort began in 1997 following a single cross that was made between ***Yumar*** (for RWA resistance) and the ***TAM 110***-derived herbicide tolerant populations. The objective of this program was to develop experimental lines combining RWA resistance and herbicide tolerance in the shortest possible time.

Grain yield, agronomic data, herbicide tolerance, RWA resistance, and end-use quality data from these preliminary trials were used as selection criteria for advancement of three lines to the 2001 UVPT in fall 2000. On average, only 25% of the group of 130 lines should carry both traits and it was quite disappointing that only three of these lines were both agronomically suitable and acceptable with respect to end-use quality. We are beginning preliminary seed increases of these three lines and, based on performance in 2001, we hope to retain at least one line for second and third year testing in the UVPT and Breeder and Foundation seed increase to enable potential release in fall 2003.

Since 1999, we have continued doubled haploid efforts with other crosses with the objective of "stacking" (also known as "pyramiding") multiple RWA resistance genes. Unfortunately, we have realized very little success and have learned that there are several steps in the process that are highly dependent on proper environmental conditions for success. A graduate student is currently working to more precisely define these environmental constraints to allow doubled haploid technology to be used more effectively.

Another procedure was used with much greater success to rapidly develop breeding lines combining herbicide tolerance and other traits. This procedure, called "single seed descent" (SSD), was used to develop a group of 503 experimental lines that were grown in a single replication preliminary trial at Fort Collins in 2000. Based on grain yield, agronomic data, end-use quality data, and uniformity of reaction to the herbicide imazamox, 43 SSD lines were selected and planted in fall 2000 in a replicated trial at five locations in eastern Colorado. Twenty-two additional doubled haploid lines, from a group of 170 doubled haploid lines not accelerated with the San Luis Valley increase in 1999, were also included in this trial along with appropriate checks and five herbicide tolerant lines from the Texas A&M-Amarillo breeding program. Seed increases (with imazamox treatment) of these lines will be done during the 2001 growing season to enable entry of a group of these herbicide tolerant lines in the 2002 Colorado UVPT in fall 2001. The earliest possible release of any of these materials would be fall 2004.

E. Advanced Yield Nursery (AYN)

In 1999-2000, the AYN included 140 experimental lines (all hard red winter wheats) and 10 check cultivars planted in a replicated trial at our five main testing locations. Based on grain yield, agronomic data, RWA resistance screening, and end-use quality data, 20 of these lines were selected and planted in fall 2000 in the UVPT.

Over the last two years, a significant enhancement at this stage of the program has been expansion of our milling and baking quality testing efforts. This necessary expansion will hopefully result in providing a much stronger set of milling and baking quality data for use in the selection process. Our overall objective for increased end-use quality emphasis is equally divided between deterring release of unacceptable-quality varieties and identifying superior quality varieties that may have potential for identity-preserved (IP) contract production. The expansion has focused on the following types of activities:

1) **USDA-ARS milling and baking evaluation**: In 1999-2000, 194 multi-location composite samples were sent to the USDA-ARS Hard Winter Wheat Quality Lab in Manhattan,

Kansas, for comprehensive milling and baking quality evaluation. A free service, this testing included all experimental lines in the AYN (140 lines), all experimental lines in the UVPT (32 lines), including herbicide tolerant lines, and 12 common check cultivars (22 samples).

2) **CSU summer screening**: Predictive quality testing was done immediately following harvest in summer 1999 and prior to planting in the fall. These tests involved protein content, grain hardness, and gluten strength (SDS sedimentation) tests routinely done at CSU but was expanded to include Mixograph testing of preliminary experimental lines (about 250 lines) prior to advancing to the AYN.

3) **CSU winter screening**: Mixograph and baking quality testing was done during the winter on remnant seed samples of lines already advanced for testing. While some of this involved evaluation of the same lines from samples from a second or third location, the majority of this testing was the addition of Mixograph testing for all entries in the PYN (775 lines) that had been advanced following post-harvest protein and SDS screening.

F. Preliminary Yield Nursery (PYN)

In 1999-2000, the PYN included 775 experimental lines planted in a single replication trial at our five main testing locations. Based on grain yield, agronomic data, RWA resistance, and end-use quality data, 140 of these lines were selected and planted in the 2001 AYN in fall 2000. Of this group, 70 are hard red and 70 are hard white. Most of the hard white lines advanced to the AYN carry RWA resistance and, based on preliminary evaluations, a smaller subset of these lines appear to combine good breadmaking and noodle quality characteristics.

As our hard white germplasm base continues to grow, we intend to work toward hard white germplasm development targeted for both the domestic and export markets (e.g., is “dual purpose”). To this end, since 1999 we have incorporated several predictive noodle quality testing procedures in addition to the various protein, SDS, Mixograph, and baking tests. These procedures include the Rapid Visco Analyzer (for noodle texture prediction and sprout damage assessment), polyphenol oxidase screening (PPO, an enzyme associated with undesirable color changes of sheeted noodles), and actual small-scale noodle tests (based on a 10 gram flour sample) where color changes are measured directly with the Minolta color meter.

G. Early-Generation Germplasm Development

In 1999-2000, we expanded significantly two key areas of the early generation germplasm development scheme. As plant breeding is often called “a numbers game”, where the probability of success is directly related to capacity to handle large numbers, it is expected that these expansions should enhance our ability to develop agronomically adapted wheat cultivars with good end-use quality characteristics. The most important areas of expansion include the following:

1) **Crossing**: over 800 crosses were made in 1999-2000, approximately a four-fold (400%) increase over recent years. While we continue to make a small (and declining) number of crosses between hard red parents (where only hard red lines will result), we are now making a much greater number of red/white and white/white crosses (with the latter only yielding hard white lines).

2) **Headrows**: over 30,000 headrows were grown in 1999-2000, approximately a three-fold (300%) increase over recent years. The number of headrows grown was previously dictated by our capacity for field RWA screening, which was limited to perhaps 10,000 rows. The primary rationalizations for this expansion include: the apparent unreliability of field-based RWA screening, the development of a greater number of resistant/resistant

crosses (where only resistant lines will result), and better Insectary facilities for more reliable greenhouse RWA screening.

III. Research Support Projects and Other Activities

In concert with the overall breeding effort, several other activities were undertaken or continued during 1999-2000. As mentioned previously, the overall objective of these activities is to contribute either directly or indirectly to improved winter wheat production and end-use quality. Examples of some of these activities are described below.

A. Breeding program efficiency

Since 1999, several efficiencies have been implemented in an overall effort to improve our capacity for handling large numbers of materials. Examples of some of these are: a relational database system to facilitate improved data and information management; a computerized label-affixing machine to streamline seed packet preparation for planting; a barcode reader system to assist with weighing plot samples at harvest; adoption of handheld computers (***Palm Pilots***) for field and greenhouse data collection; spraying of field-plot alleys with ***Roundup*** in May rather than harvesting the wheat in the alleys with a combine in July.

B. Public-counterpart collaboration

Beginning in fall 1999, we established structured interactions with the public breeding programs at Texas A&M University-Amarillo, Kansas State University-Hays, and University of Nebraska-Lincoln. As part of this effort, we now systematically exchange advanced breeding lines and test these at our respective locations. For example, all CSU experimental lines in the UVPT are now grown in a replicated trial at one location in each of the other three states while we plant a replicated trial of advanced lines from each of the other three programs at one of our locations. The main advantage of this effort, from our perspective, is that we have an opportunity to see a greater range of breeding material (and potential parents for crossing) in our own testing environments. In addition to this reciprocal testing, we have also reciprocally-shared early-generation bulk populations (e.g., F_2 populations) with Kansas State University-Hays and University of Nebraska-Lincoln.

C. Web-based variety information

A relational database system was implemented on the Internet/World Wide Web (***http://triticum.agsci.colostate.edu***) to provide complete access to winter wheat variety information and variety trial data. All dryland and irrigated data since 1990 are included. In addition to information on variety characteristics and summaries from individual trial locations, users can direct the database to provide multi-location/multi-year data summaries based on user-specified criteria and "head-to-head" comparisons between two user-specified varieties. We hope that this effort will help wheat producers, crop consultants, and extension agents and enhance the variety selection decision-making process.

D. Graduate student research

Several graduate student research projects are currently underway. Briefly, these include the following important areas of research: inheritance and chromosomal location of a new wheat streak mosaic virus (WSMV) resistance gene; environmental influence and genotype x environment interaction for key noodle quality characteristics; improvement of the wheat x maize doubled haploid system; identification of associated advantages and disadvantages of semidwarfing genes (of European origin) that that do not reduce coleoptile length. While we hope that some of these projects will contribute vital information to direct the breeding program, the students also benefit by receiving a strong graduate training opportunity.