The Quality of Some Semidwarf and Conventional Height Hard Red Spring Wheat Varieties

L. D. Sibbitt

INTRODUCTION

From time to time, for various reasons, new wheat varieties are developed and released for commercial production. The reputation North Dakota has gained for the production of high quality hard red spring wheat is enviable in both domestic and foreign markets. Due to excellent quality, the export market demand for this class of wheat has nearly doubled in the past 10 years. This is a very significant and valuable asset to North Dakota as this state provides more than 50 per cent of the total U.S. hard red spring wheat production. This position should be maintained and expanded if possible.

It has been the practice in the past that before a potential new wheat variety is considered for release, it must have satisfactory agronomic and quality characteristics over a period of at least three consecutive years of testing. Specifically, before a potential variety is given the "green light" for quality, it must possess characteristics that equal current commercially-produced wheats in all major factors examined and better in some.

In the past few years, new varieties from various sources have been grown commercially in North Dakota. Many of these, but not all, have been of the semidwarf type. The last "variety survey" (1969 crop) made in North Dakota reported that less than two per cent of the acreage was seeded to semidwarf type wheats. An estimated six or seven per cent of the 1970 North Dakota hard red spring wheat acreage was seeded to semidwarfs.

Produce All Kinds

It appears that in the forseeable future, North Dakota and the Upper Great Plains in general will continue to produce conventional height varieties and, in addition, semidwarfs and possibly hybrids. Hybrids at the present time, according to plant breeders, are still about five years away for the spring wheat area. Meanwhile, good quality conventional varieties must still be developed and increased for ultimate commercial production. However, commercial production of semidwarfs is present now. It is imperative that these wheats be examined very carefully to guard against their widespread growth should they be unacceptable from a quality or agronomic standpoint. This article, therefore, deals principally with semidwarf wheats and their current quality status in North Dakota and the Upper Great Plains in general.

The story of semidwarf varieties in North America began in 1946 when Dr. S. C. Salmon, a USDA plant breeder, observed while on a trip to Japan that farmers were obtaining exceptional yields from stiff-strawed wheats that reached a height of no more than 24 inches. One of these varieties which appeared to be better than the others was named Norin-10. Half of the parentage of this variety was the result of a cross of Turkey Red and Fulz-Daruma, both of which were prominent in the United States about 30 years ago.

Norin-10, by itself, proved to be unsatisfactory, but eventually this variety became the predominant parent in a number of new varieties. In 1961, Gaines, a white wheat, was released by Washington State University and was the first semidwarf to be released and widely grown in the United States.

Looking for High Yield

In 1959, wheat breeders associated with the Rockefeller Foundation in Mexico incorporated Norin-10 in their spring wheat breeding program. Since 1962, this variety development team in Mexico has released a number of semidwarf varieties. However, the primary purpose of this program was to develop high yielding wheats purely from the standpoint of feeding "hungry bellies", rather than from the aspect of other quality characteristics such as the production of quality flour and bread as it is known in the United States. This semidwarf variety program has now changed Mexico from an importing country to an exporting country of wheat. In addition, some of these varieties are being produced commercially in Pakistan, India, Turkey and other mid-eastern countries to the extent that possibly they may become self-sufficient in wheat production.

It is prudent to keep in mind that the Mexican program was directed toward the development of new wheat varieties which could grow under irrigation and where heavy rates of fertilizer could be applied. Because of the shorter, stiffer straw, these

Sibbitt is associate professor, Department of Cereal Chemistry and Technology.

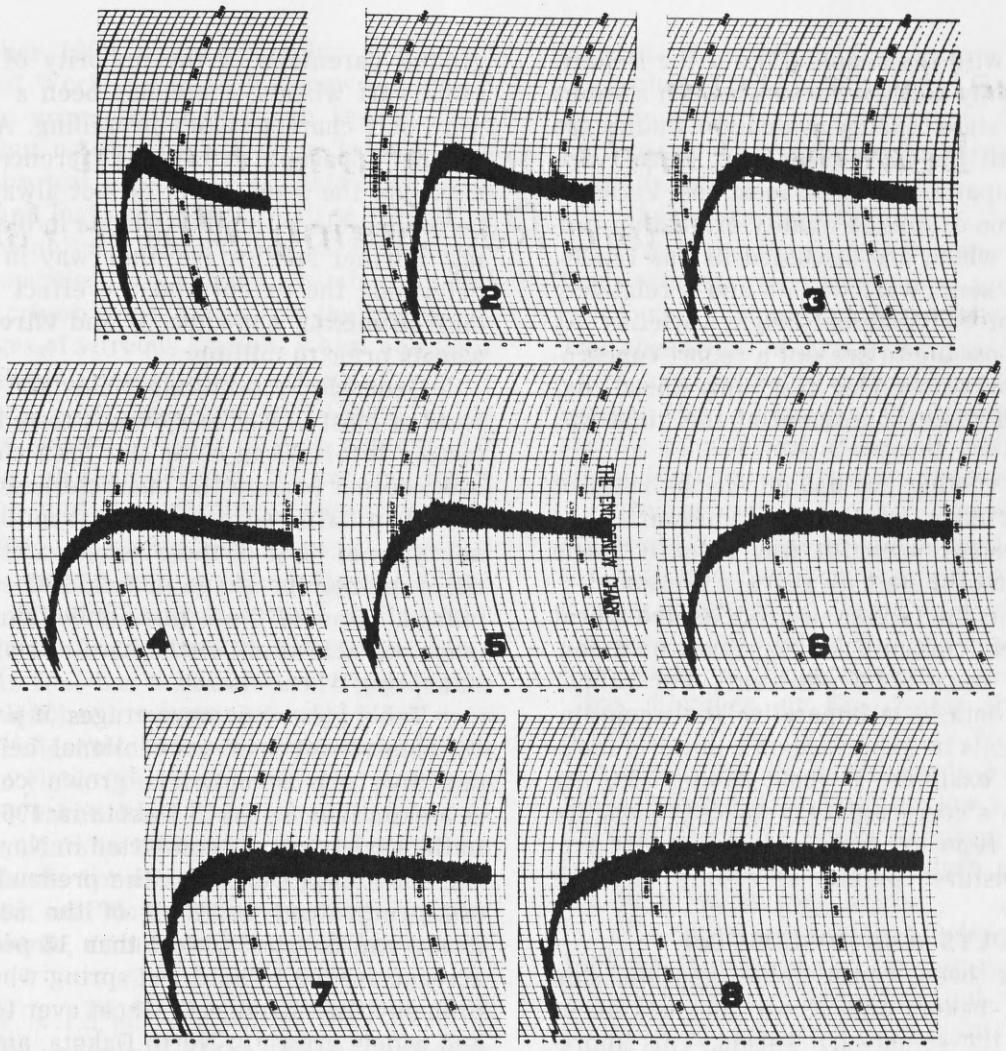

Figure 1. Reference Farinograms, Hard Red Spring Wheat.

semidwarfs also are less likely to lodge. Under these conditions, an advantage of many of the semidwarf varieties is their insensitivity to the number of daylight hours. Many of the standard varieties grown in the spring wheat area are daylight sensitive, which means that it is necessary to have a certain number of hours of daylight each day for a plant to properly develop. These new varieties that are insensitive to day length can be raised in many geographic regions of the world which formerly were not suited for wheat growth.

Many Commercial Semidwarfs

Since 1961, when Gaines was released, many semidwarfs have been released and were or are being grown commercially. Some of these have better agronomic and quality characteristics than the varieties they replaced, others do not.

North Dakota State University has been making crosses, growing and testing for quality semidwarf wheats both hard red springs and durums since 1956. In addition, many of the Mexican lines have been tested both from an agronomic and quality standpoint. None of these lines or the crosses made at Fargo have proved to be equal in agronomic and/or quality characteristics to the standard named varieties grown commercially.

In the interim, a number of semidwarf hard red spring wheats have been released by private seed companies in the Upper Great Plains. World Seeds, Incorporated, has released Red River 68, World Seeds 1812 and World Seeds 1809. DeKalb AgResearch, Incorporated, has released Bonanza; and Cargill, Incorporated, just recently (November, 1970) released Bounty 208. On April 15, 1970, the Minnesota Agricultural Experiment Station released Fletcher and Era.

MATERIAL AND METHODS

To properly assess quality of a potential new variety, it must be grown comparably at a number of locations throughout the area for a number of years, and tested for quality by approved laboratory methods (1).

Each year with the cooperation of the Department of Agronomy and the various branch stations throughout the state, quality evaluation studies are conducted on all the hard red spring wheat varieties grown comparably at these locations. Varieties under test in this expanded quality evaluation program, some of which are discussed in this report, consisted of 12 semidwarf wheats and a relatively large number of conventional height varieties. As it would be impossible to present a report concerning all of the wheats under test, only those that appear to be of greatest interest at this time will be discussed.

A study involving the use of various rates of commercial fertilizer applied to semidwarfs and conventional height varieties was recently made (5) (6). A portion of these data also are presented.

Note that in the tables, absorptions and wheat and flour protein contents are expressed on a constant moisture basis (14.0 per cent). For proper comparison of data, it is imperative that quantitative measurements be expressed on a uniform moisture basis. For example, a wheat having 13.5 per cent protein on a corrected 14.0 per cent moisture basis would be reported to have 14.0 per cent protein if the moisture content were only 11.0 per cent.

RESULTS AND DISCUSSION

There has been considerable apprehension among millers, bakers and cereal chemists about the quality of the semidwarf wheats. This apprehension perhaps has been precipitated by the experience with the early semidwarfs which were developed originally at Washington State University and later at the Rockefeller Foundation in Mexico. Because of the soft kernel types in the background parentage of the majority of the present semidwarf wheats, there has been a tendency toward soft characteristics in milling. Also, because of the apparent extreme difference in genetic make-up, the semidwarfs do not always appear to be compatible with other wheats in blends for milling. Further studies are underway in this area to determine the extent and the effect of the influence of mixing non-vitreous and vitreous types of wheats prior to milling.

Generally, the milling yields and the ash contents of most of the semidwarfs tested are at satisfactory levels. Bran color and bran clean up, however, do not possess the characteristics usually observed in hard red spring wheat milling. The kernel types of most of these semidwarfs do not have the color nor the shape of hard red spring wheat; indeed, some of these lines only faintly resemble wheat kernels of either the hard red winter or hard red spring wheat classes.

Table I shows some averages of pertinent quality data (2) for four conventional height varieties and five new semidwarfs grown comparably at seven stations in North Dakota in 1969. According to the variety survey conducted in North Dakota on the 1969 crop, Chris was the predominant variety occupying about one-third of the acreage, while Justin had dropped to less than 13 per cent of the acreage seeded to hard red spring wheat. Justin is probably the "strongest" wheat ever to be released and widely grown in North Dakota, and is included in this table to provide a more or less upper level yardstick for comparative purposes only. Red River 68, although occupying less than two per cent of the acreage in 1969, is also included for comparative purposes.

Table 1. Pertinent average quality data for five conventional height varieties and five semidwarf varieties. North Dakota Field Plot Variety Trials — 7 Stations — 1969 Crop

	Yield[1]	Test Weight	Protein[2] Wheat	Protein[2] Flour	Absorp.[2]	Dough[3]	Loaf Volume	Crumb Grain & Texture[4]	Mix Time	Farinogram[5]
	b.p.a.	lbs./bu.	%	%	%		cc.		min.	classif.
Conventional										
Chris	42.7	61.4	15.3	14.5	65.8	4	911	8.5	5.9	6
Justin	42.0	60.9	15.4	14.6	66.4	4	916	8.6	6.8	7
Manitou	46.9	60.9	15.1	14.3	64.6	4	832	8.6	5.6	5
Waldron	45.2	60.7	15.5	14.6	65.2	4	899	8.2	5.3	5
Semidwarfs										
Red River 68	45.7	62.1	14.5	14.0	64.5	2	761	7.9	9.2	8[6]
W.S. 1812*	44.8	62.0	14.3	13.3	63.6	3	831	8.1	4.6	3
Fletcher	51.5	61.3	13.8	12.9	63.7	4	801	8.1	5.1	4
Era	55.9	61.7	13.1	12.2	61.9	3	792	8.3	5.3	4
W.S. 1809*	49.2	61.5	14.5	13.5	63.3	4	884	8.6	5.8	5

*W.S. — World Seeds.
[1]Data supplied by Department of Agronomy, NDSU.
[2]Expressed on 14.0% moisture basis.
[3]Dough handling properties: 4, good; 3, fair; 2, poor; 1, very poor.
[4]Bread crumb grain and texture, 9.0 to 10.0, excellent; 8.0 to 8.9, good; 7.0 to 7.9, fair; 6.0 to 6.9 poor.
[5]See Figure 1 for reference farinograms.
[6]Abnormal curve type.

In October, 1969, World Seeds, Inc. announced the release of World Seeds 1812, a new semidwarf variety. Data accumulated at North Dakota State University, but not all of it shown in Table I, indicates that the test weight, flour yield, flour ash, crust color and loaf symmetry are all at acceptable levels. Minor faults of World Seeds 1812 are dough handling properties, loaf volume, crumb grain and texture and crumb color. The major faults are lower percentages of vitreous kernels, wheat and flour protein contents, absorptions and weak mixing characteristics. When compared with Chris, 1812 is 1.0 per cent lower in wheat protein content, 1.2 per cent lower in flour protein, 2.2 per cent lower in absorption and considerably lower in mixing characteristics.

The variety Fletcher, as previously stated, was developed and released by the Minnesota Agricultural Experiment Station. It is one of the few semidwarf wheats that has a visual kernel appearance akin to a typical hard red spring wheat. When compared with Chris, Fletcher is about the same in test weight, flour yield, flour ash, crust color and symmetry of the baked loaf. A minor fault found in this wheat appears to be crumb grain and texture. The major faults consist of lower vitreous kernel content, wheat and flour protein contents, absorption, loaf volume, crumb color and mixing characteristics.

Fletcher is 1.5 per cent lower than Chris in wheat protein content and 1.6 per cent lower in flour protein. It is also 2.1 per cent lower than Chris in absorption.

Era, the other Minnesota release, also has visual kernel characteristics somewhat similar to Fletcher. As shown in Table 1, the test weight of this new semidwarf is almost the same as Chris. However, some 1968 test weight data places Era significantly higher than Chris. In this comparison, flour yield for Era was higher than Chris, but so was flour ash. The major faults of Era when compared with Chris are lower wheat and flour protein contents, absorption, dough handling properties, loaf volume, crumb color, crust color and symmetry. Minor faults are a tendency toward a larger percentage of non-vitreous kernels and mixing characteristics.

These data show Era to be 2.2 per cent and 2.3 per cent lower than Chris in wheat and flour protein contents, respectively. It is more than 0.5 per cent lower in wheat and flour protein than Fletcher. The absorption of Era is 3.9 per cent lower than Chris and produced a loaf volume 14 per cent smaller than Chris. For these reasons, the North Dakota Experiment Station is not recommending either Fletcher or Era for commercial production.

On September 30, 1970, World Seeds, Inc. announced the release of World Seeds 1809. Some of the pertinent data accumulated on this semidwarf is also presented in Table I. Based on a limited number of tests for only one year, it appears that test weight of this semidwarf is about the same as Chris, Fletcher, or Era, better than Manitou or Waldron, but not quite equal to World Seeds 1812. The flour yield of World Seeds 1809 is relatively high coupled with a desirable low ash content. Mixing characteristics, dough handling properties, loaf volume, crumb grain and texture and crumb color are all at satisfactory levels.

The undesirable quality factors of World Seeds 1809 are low wheat and flour protein contents and low absorption. When compared with Chris, this semidwarf is 0.8 percentage points lower in wheat protein and 1.0 percentage points lower in flour protein. The absorption of World Seeds 1809 is 2.5 percentage points lower than Chris, and with the exception of Era, it is the lowest in this comparison.

Early in January, 1970, Bonanza, another new semidwarf, was released by DeKalb AgResearch, Inc. Table 2 presents averages of pertinent data (3) for Bonanza and Chris grown comparably this past year at six locations in North Dakota.

In this experiment, Bonanza was found to have, on the average, satisfactory flour yield and flour ash level. It is, however, lower than Chris in

Table 2. Pertinent average quality data for Chris (conventional height variety) and Bonanza (semidwarf variety). North Dakota Field Plot Variety Trials — 6 Stations — 1969 Crop

	Yield[1]	Test Weight	Protein[2] Wheat	Protein[2] Flour	Absorp.[2]	Dough[3]	Loaf Volume	Crumb Grain & Texture[4]	Mix Time	Farinogram[5]
	b.p.a.	lbs./bu.	%	%	%		cc.		min.	classif.
Chris	40.9	60.9	16.0	15.2	65.6	4	936	8.6	5.8	6
Bonanza	49.1	59.3	14.7	14.1	62.4	4	903	8.3	7.8	6

[1]Data supplied by Department of Agronomy, NDSU.
[2]Expressed on 14.0% moisture basis.
[3]Dough handling properties, 4, good; 3, fair; 2, fair; 1, very poor.
[4]Bread crumb grain and texture, 9.0 to 10.0, excellent; 8.0 to 8.9, good; 7.0 to 7.9, fair; 6.0 to 6.9, poor.
[5]See Figure 1 for reference farinograms.

Table 3. Pertinent quality data for Waldron, Fletcher and Era grown in California — 1969-70 crop.

Grown in California — 1969 — 70 Crop

	Test Weight	Vitreous Kernels	Wheat Protein[1]	Absorption[1]	Dough[2]	Loaf Volume	Crumb[3] Grain & Texture	Mix Time	Mix-ogram
	lbs/bu.	%	%	%		cc.		min.	classif.
Waldron	59.7	98	12.6	64.4	3	150	8.0	3.5	4
Fletcher	59.3	74	10.4	62.8	2	130	7.5	3.5	4
Era	61.6	66	9.3	60.8	2	120	7.0	3.5	4

[1]Expressed on 14.0% moisture basis.
[2]Dough handling properties; 4, good; 3, fair; 2, poor; 1, very poor.
[3]Bread crumb grain and texture, 9.0 to 10.0, excellent; 8.0 to 8.9, good; 7.0 to 7.9, fair; 6.0 to 6.9, poor.

percentage of vitreous kernels, test weight, wheat and flour protein and absorption. In this series, bread made from Bonanza produced satisfactory loaf volumes coupled with good external and internal characteristics. Bonanza required a little longer mixing time than Chris, but the overall farinogram curve characteristics were similar to Chris.

In general, the major faults exhibited by Bonanza, when compared with Chris, were 1.6 pounds per bushel lower test weight; 1.3 per cent lower wheat and 1.1 per cent lower flour protein; and 3.2 per cent lower absorption.

Although not shown here, data have been accumulated in the NDSU quality laboratory on two samples of Bounty 208 for one year. The Crop Quality Council provided the 1969 crop samples which were grown comparably with Chris, the check variety. Based on these two tests it appears that the major faults of Bounty 208 when compared with Chris were lower wheat and flour protein contents, absorptions and loaf volumes. The other quality characteristics were more or less at acceptable levels.

Table 3 shows some quality data (4) for two semidwarfs, and Waldron, a conventional height variety, all grown comparably in California. Both of the semidwarfs held up well in test weight. However, the vitreous kernel content of Fletcher is only about 74 per cent, with Era 66 per cent, and Waldron 98 per cent. The wheat protein is 2.2 per cent below Waldron for Fletcher and 3.3 per cent below Waldron for Era. The absorption is also 1.6 and 3.6 per cent below Waldron for Fletcher and Era, respectively. Loaf volumes, as shown, are in line with the protein content. Mixing characteristics were the same for the three varieties. However, Waldron usually displays mixing characteristics that are stronger than the classification of "4" shown here. In general, in this limited experiment, the differences displayed by these semidwarfs are apparent whether grown in North Dakota or California.

Certain proponents of semidwarf wheats have claimed that another advantage is their response to heavy fertilization, and in particular, nitrogen, which not only produces higher yields but higher protein contents as well. A search of the literature revealed that there is very little information published about the response of semidwarf wheats to so-called high fertility levels. Therefore, in 1969, an intensive study involving five varieties, five levels of nitrogen fertilizer, on both dryland and irrigated plots, was undertaken at the North Dakota Branch Experiment Station at Carrington. An elaborate detailed discussion of the agronomic (5) and quality (6) data accumulated from this experiment has been published. Table 4 shows some of the pertinent data obtained for Waldron, the check variety, and three of the more important semidwarf wheats, at three fertilizer levels from the dryland plots only.

These data show that the yield of bushels per acre were quite similar for all varieties when there was no nitrogen applied to the plots. Yield increased with increasing amounts of nitrogen added for all the varieties with the exception of World Seeds 1812. Test weight decreased with increasing nitrogen levels in all varieties with the exception of Red River 68. Bonanza appears to be particularly prone to have an excessive reduction in test weight with increasing amounts of nitrogen fertilizer.

The protein content of the semidwarfs at zero nitrogen treatment is 3.3 per cent below the check variety, Waldron. With 50 pounds of nitrogen applied, the protein content of Red River 68 was 2.7 per cent, World Seeds 1812, 3.6 per cent and Bonanza, 2.2 per cent below the comparably grown check variety, Waldron. With 100 pounds of nitrogen added, the semidwarfs were still lower in protein content than the comparably grown check variety. Loaf volumes of the semidwarfs were all lower than the check and were at unacceptable levels with the exception of Bonanza at the 50 and 100 pound levels of fertilizer application.

Although not shown here, the absorptions of the semidwarfs were all significantly lower than the check and were, in some instances, as much a

Table 4. Pertinent quality data showing the effect of various amounts of nitrogen fertilizer on Waldron and three Semidwarf Wheats.

CARRINGTON DRYLAND PLOTS — 1969 CROP

	Fert. Treat	Yield	Test Weight[1]	Protein[1]		Absorp.[1]	Dough[2]	Loaf Volume	Crumb Grain & Texture[3]	Mix Time	Farino-gram
				Wheat	Flour						
	N lbs./Ac.	b.p.a.	lbs./bu.	%	%	%		cc.		min.	classif.
Waldron	0	35	62.2	15.0	14.1	65.7	4	845	8.5	7.5	6
Waldron	50	44	61.8	15.8	15.2	67.3	4	840	8.5	6.5	6
Waldron	100	52	61.6	15.5	15.1	67.7	4	930	8.5	6.5	5
Red River 68	0	33	63.4	11.7	11.4	63.4	3	580	5.5	13.0	8[5]
Red River 68	50	48	63.1	13.1	12.3	66.6	2	625	5.5	14.0	8[5]
Red River 68	100	54	63.9	12.4	12.0	66.5	2	625	5.5	12.5	8[5]
W.S. 1812*	0	37	63.9	11.7	11.3	63.9	4	700	6.0	5.5	3
W.S. 1812*	50	47	63.7	12.2	11.8	64.1	4	710	7.5	5.5	2
W.S. 1812*	100	47	62.7	13.2	12.3	63.8	4	685	6.0	6.5	3
Bonanza	0	38	63.5	11.7	11.3	60.6	4	730	7.5	5.0	7[5]
Bonanza	50	51	61.4	13.6	13.0	61.6	4	820	8.5	7.0	8[5]
Bonanza	100	56	60.6	13.8	13.4	61.3	4	800	8.5	8.0	8[5]

*W.S. — World Seeds.
[1]Expressed on 14.0% moisture basis.
[2]Dough handling properties; 4, good; 3, fair; 2, poor; 1, very poor.
[3]Bread crumb grain and texture, 9.0 to 10.0, excellent; 8.0 to 8.9, good; 7.0 to 7.9, fair; 6.0 to 6.9, poor.
[4]See Figure 1 for reference farinograms.
[5]Abnormal curve type.

6.4 per cent lower. It was also apparent from this study that with the exception of World Seeds 1812, the addition of even small amounts of fertilizer, when applied to the semidwarfs, produced farinogram curve types which were classified as "abnormal," indicating "tough" gluten properties. In addition, this study showed that regardless of the amount of fertilizer used (even as high as 200 pounds of nitrogen per acre) the protein contents of the semidwarfs never reached the level of the comparably grown check variety. The maximum level of wheat protein of any of the semidwarfs was still below the protein content reported for the variety Waldron from the untreated plots.

In general, it appeared that the treatment of the plots with various amounts of nitrogen fertilizer did not produce quality characteristics in the five semidwarfs in this test that were equal or superior to the comparably grown conventional height variety, Waldron.

SUMMARY

In summary, although only certain varieties have been discussed, it appears that all of the semidwarfs developed for the hard red spring wheat area and tested for quality in the Department of Cereal Chemistry and Technology laboratory thus far are deficient in wheat and flour protein contents and absorption. In addition, in some instances the varieties also have other major faults which make them still more unacceptable.

Due to technical problems, the commercial production of hard red spring hybrid wheat is still a considerable number of years away, according to the plant breeders. Therefore, it is imperative in the meantime that we continue to develop the conventional height wheat varieties that possess good quality.

The plant breeder has a wide range of semidwarf material to work with. It is possible that a semidwarf variety acceptable to the producer, the miller, the baker and the ultimate consumer could be developed for the Upper Great Plains in the near future.

Although we do not know all that is needed to know about the production and quality characteristics of semidwarf wheats, they may eventually become a transition between the conventional height varieties which we have today and the hybrids that may be coming in the future.

ACKNOWLEDGEMENT

The author is grateful for the technical assistance provided by Truman C. Olson and Clayton A. Roen.

REFERENCES

1. American Association of Cereal Chemists. AACC Approved Methods. The Association: St. Paul, Minnesota. 1962.
2. Field Plot Variety Trial Report (HRS) - 1969 Crop on file, Dept. of Cereal Chemistry and Technology, NDSU.
3. Late Seeded Variety Trial Report (HRS) - 1969 Crop on file, Dept. of Cereal Chemistry and Technology, NDSU.
4. Special Study on California Grown Wheats (HRS) - 1969 Crop on file, Dept. of Cereal Chemistry and Technology, NDSU.
5. Bauer, Armand. "Effect of Fertilizer Nitrogen Rate on Yield of Six Spring Wheats" North Dakota Farm Research, 27: 4, 1970.
6. Sibbitt, L. D. and Bauer, Armand. "Effect of Fertilizer Nitrogen Rate on the Quality of Six Hard Red Spring Wheats" North Dakota Farm Research, 27: 6, 1970.