Quality Comparisons of Some Semidwarf and Standard Height Hard Red Spring Wheat Lines Grown in Montana[1]

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ABSTRACT

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Development of high yielding cultivars with acceptable milling and bread-baking potential constitutes a major objective in the Montana hard red spring wheat breeding program. This report summarizes data comparing experimental semidwarf lines with four standard height cultivars grown at six locations during 1965–1974. Standard quality evaluation procedures showed that, compared with standard height wheat, semidwarf had lower flour yield in six years and lower flour ash in three years; lower farinograph absorption values in one year but similar values in seven years; longer dough stabilities in one of eight years; equal flour protein content in six years and lower in four years by as much as 0.9 percentage points; equal loaf volume in nine years and larger in one year; equal crumb scores in all but one year; higher bake absorption in one year, lower in three years, and equal the other six years; and slightly longer dough-mixing requirements in four of the 10 years. Selection to improve milling and other hard wheat quality traits of semidwarf wheats produced lines suitable for commercial production. However, the tendency for slightly lower protein content and flour yield persists.

Short statured wheats often yield more than do standard height wheats (Anonymous 1968, Gilles 1968, McNeal et al 1972, Reitz 1968), and as a result, plant breeders are interested in developing short strawed cultivars. If these short strawed, high yielding wheats have acceptable milling and baking qualities, they will, when made available to commercial grain producers, immediately increase income without requiring land expansion. Historically Norin 10 has been an important source of short strawed wheats in many breeding programs (McNeal et al 1960, Reitz and Salmon 1968). Because this cultivar offers little in agronomic adaptation, milling, or bread-baking quality, a diversity of plant types and quality characteristics results from its crosses (McNeal et al 1971, Porter et al 1964). Abrol et al (1972) found marked differences in mixograph traits among semidwarf (SD) cultivars. They found protein content significantly correlated with mixogram curve height, rate of dough weakening, and developmental area. Unver and McDonald (1976) selected SD wheats with low water absorption to compare with standard height (SH) wheats. They found that the starch fraction from SD had higher water binding capacity than did starch from SH wheats but that the sludge fraction from the SD was lower in water binding capacity. Gluten fractions had similar water binding capacity for the two wheat types (Gilles (1968) found selected SD to equal or exceed SH checks in grain protein content, test weight, flour yield, flour ash percent, loaf volume, and farinograph peak time. Other SD lines exhibited low test weight and 1,000-kernel weight (Joppa 1973) and low bake absorption, loaf volume, vitreous kernel number, and farinograph absorption (Gilles 1968). Because of poor milling and baking quality, some commercially grown SD have value only as lievestock feed (Reitz and Salmon 1968). Other cultivars are of acceptable milling and baking quality (Gilles 1968, Reitz 1968).

A major objective of the hard red spring wheat breeding program in Montana is to develop and release high yielding cultivars. However, such cultivars must have adequate grain protein potential, milling yield, and bread-baking quality. This paper reports comparisons in milling and baking quality betwen SD lines and SH wheats. Since SD lines were continually being introduced and deleted, the year to year progress in average SD quality may be assessed.

MATERIALS AND METHODS

We evaluated experimental lines and check cultivars grown in the Advanced Yield Nursery from 1965 through 1974 for plant height and grain yield. Those lines significantly shorter than the average height of check cultivars Centana, Manitou, Thatcher, and Fortuna were considered to be SD. Numbers of selections thus classified in each year are listed in Table I. Pedigrees of these selections included Norin 10/Brevor, CI 13253, as a common parent. We kept SD lines meeting both agronomic and quality performance standards in the testing program for more than one year but dropped poor performers after one year's testing. Thus, the population of SD lines changed from year to year.

Quality data were analyzed statistically to determine whether SD differed from SH wheats. Data from all 10 years were combined. The mean of SD lines was considered as one cultivar and the mean of SH cultivars as the second cultivar. Year to year progress in quality improvement was evaluated by comparing SD lines with SH wheats each year.

Loaf volume regressed on flour protein content allowed a comparison of the baking quality per unit of protein in SD and SH wheats. Grain yield regressed on flour protein content provided a comparison of the rate of protein reduction of SD vs SH as grain yields increased.

Because field replication failed to produce adequate seed for quality tests by replication, each location was used as a replication.

Analytical methods used to obtain quality data have been described previously (McNeal et al 1971).

RESULTS

Our major interest was in comparing quality criteria mean scores of SD and SH wheats. Mean SD test weight was significantly lower in three of the 10 years than that of SH wheats but similar in the other seven years (Table II). Flour yield of the SD was less than that of the SH wheats in five of the 10 years.

Water absorption values, in either the bake or the farinograph test, were not significantly different between the two wheat types in six of the 10 years (Table II). In 1965, farinograph absorption data were not recorded, but in the bake test the SD flour averaged 2.6% less than SH flour. Farinograph and bake absorption values of SD wheats in 1966 were significantly above those obtained with SH. Absorptions of the SD were below those of SH wheats in 1968 and 1971 in the bake test.

Farinograph peak times of SD averaged higher than those of the SH wheats in only one year, 1971. Dough stability was longer for the SD only in 1968, but the trend for long stability appeared in six

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years.

SD wheats generally had lower flour protein than did SH wheats. Flour protein was significantly less in four of the 10 years, but mean differences were never more than 0.9% in favor of the SH wheats. Wheat protein data were available only for 1970 through 1974. For those five years, the SH checks averaged a loss in protein from wheat to flour of 1.3, 1.3, 1.2, 1.1, and 1.3 percentage points respectively. SD wheats averaged 1.2, 1.6, 1.0, 1.2, and 1.5 percentage points loss, respectively, for the same years.

Baking quality reflects protein quality, and loaf volume is the best estimate of bread wheat baking quality. SD baked as well as SH wheats, on the average, in every year. This suggests that the baking quality of protein in SD genotypes is desirable even though the quantity may be less than in the SH wheats. Figure 1 compares

TABLE I
Number of Semidwarf Hard Red Spring Wheats Grown Each Year in the Advanced Yield Nursery

Year	Number	Locations
1965	5	7
1966	2	8
1967	1	5
1968	8	6
1969	11	6
1970	11	6
1971	7	5
1972	11	5
1973	10	6
1974	13	6

TABLE II
Quality Criteria Means[a] Showing Difference in Each Year Between Semidwarf (SD) and Standard Height (SH) Wheats Grown in Montana in the Advanced Yield Nursery, 1965 through 1974

Year	Cultivar type	Test Weight (kg/hl)	Flour Yield (%)	Flour Ash (%)	Farinograph Abs. (%)	Farinograph Peak (min)	Farinograph Stability (min)	Flour Protein (%)	Bake Abs. (%)	Bake Mix Time (min)	Bake Loaf Vol. (cc)	Bake Grain and Texture
1965	SD	70.8 a	68.1 a	0.492 a	···	6.3 a	16.9 a	12.9 a	56.3 a	3.2 a	842 a	4.9 a
	SH	76.3 b	71.5 b	0.491 a	···	6.5 a	13.6 a	13.3 a	59.5 b	2.8 a	864 a	5.4 a
1966	SD	77.6 a	68.5 a	0.443 a	65.1 b	7.6 a	13.8 a	13.8 a	63.0 b	2.8 a	983 a	4.9 a
	SH	76.7 a	69.6 a	0.455 a	63.5 a	7.0 a	14.9 a	13.8 a	60.6 a	2.7 a	953 a	4.8 a
1967	SD	79.0 a	67.4 a	0.444 a	66.1 a	6.5 a	17.1 a	13.5 a	61.6 a	3.0 a	1,095 b	4.6 a
	SH	79.2 a	68.9 a	0.447 a	66.0 a	6.3 a	10.0 a	12.7 a	61.6 a	2.6 a	872 a	4.8 a
1968	SD	74.9 d	67.4 a	0.430 a	60.5 a	6.4 a	16.3 b	12.9 a	58.5 a	3.0 b	948 a	4.0 a
	SH	76.5 b	70.8 b	0.454 b	61.3 b	5.6 a	9.1 a	13.3 a	60.3 b	2.6 a	951 a	4.5 b
1969	SD	78.5 a	68.9 a	0.462 a	62.2 a	4.6 a	5.7 a	12.2 a	60.8 a	1.8 a	969 a	4.7 a
	SH	79.5 a	70.9 b	0.455 a	62.3 a	4.6 a	5.4 a	13.1 b	61.2 a	1.7 a	958 a	4.7 a
1970	SD	78.3 a	69.7 a	0.433 a	61.4 a	7.4 a	15.1 a	13.4 a	59.5 a	2.1 b	1,038 a	4.3 a
	SH	78.6 a	70.6 a	0.433 a	61.9 a	6.1 a	12.0 a	14.2 b	60.4 a	1.7 a	1,051 a	4.4 a
1971	SD	78.3 a	69.8 a	0.413 a	60.3 a	7.3 b	19.2 a	13.4 a	61.2 a	2.4 b	968 a	4.1 a
	SH	78.3 a	70.0 a	0.405 a	61.3 a	6.0 a	14.6 a	13.7 a	62.2 b	1.8 a	994 a	4.5 a
1972	SD	77.9 a	68.2 a	0.412 a	60.2 a	4.4 a	6.4 a	12.3 a	61.6 a	2.0 a	947 a	4.1 a
	SH	77.5 a	71.2 b	0.419 a	60.7 a	4.9 a	6.6 a	13.0 b	61.9 a	1.9 a	946 a	4.2 a
1973	SD	73.2 a	63.4 a	0.437 a	61.5 a	7.6 a	21.2 a	13.8 a	60.9 a	2.4 b	988 a	4.0 a
	SH	74.7 a	66.6 b	0.469 b	61.5 a	7.2 a	17.5 a	14.6 a	60.8 a	2.1 a	996 a	4.2 a
1974	SD	75.6 a	67.1 a	0.438 a	59.8 a	4.9 a	14.7 a	13.7 a	62.1 a	2.3 a	1,057 a	4.7 a
	SH	75.0 a	68.7 b	0.509 b	59.4 a	4.6 a	10.0 a	14.6 b	63.2 a	2.2 a	1,058 a	4.5 a

[a]Within each year and in each column, means followed by different letters were different according to Duncan's multiple range test, $P = 0.05$.

TABLE III
Comparison of Commercially Available Semidwarf (SD) Wheats and Standard Height (SH) Check Cultivars[a]

Variety[b]	CI No.	Test Weight (kg/hl)	Flour Yield (%)	Flour Ash (%)	Farinograph Abs. (%)	Farinograph Peak (min)	Farinograph Stability (min)	Flour Protein (%)	Bake Abs. (%)	Bake Mix Time (min)	Bake Loaf Vol. (cc)	Bake Grain and Texture
Newana	17430	78.1 b	66.3 a	0.426 a	62.2 b	6.5 a	16.4 b	13.0 a	62.0 a	2.3 a	1,036 a	5.3 b
X of SH wheats[c]		75.6 a	68.8 b	0.459 b	60.8 a	5.7 a	11.7 a	14.4 b	62.3 a	2.0 a	1,010 a	4.3 a
Norana	15927	77.0 a	66.2 a	0.445 a	63.0 b	6.3 a	16.1 a	12.7 a	62.9 a	2.1 a	1,000 a	4.7 a
X of SH wheats[c]		76.2 a	69.1 b	0.445 a	61.0 a	5.8 a	12.5 a	14.2 b	62.3 a	2.0 a	1,006 a	4.4 a
Shortana	15233	75.6 a	67.7 a	0.426 a	60.7 a	5.9 a	16.2 a	13.4 a	61.5 a	2.1 a	1,021 a	5.0 a
X of SH wheats[c]		76.6 a	69.4 b	0.442 b	61.2 a	5.9 a	12.3 a	14.2 a	61.9 a	1.9 a	1,019 a	4.4 a

[a]Different letters following each pair of quality traits show statistically significant differences between each SD cultivar's mean and the mean of the checks.
[b]Data for Newana were obtained from 17 station-years, for Norana 24 station-years, and for Shortana 28 station-years. Check data were from comparable plots in the time period corresponding to each SD cultivar.
[c]Four SH wheats: Centana, Manitou, Thatcher, and Fortuna, grown in the same number of station years as each of the three SD cultivars.

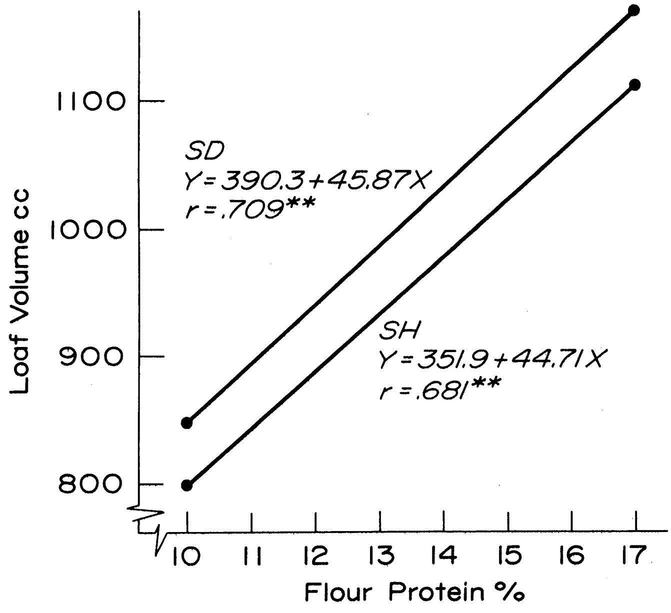

Fig. 1. Regression of loaf volume on flour protein content of semidwarf (SD) and standard height (SH) wheats grown in the Advanced Yield Nursery from 1965 through 1974.

loaf volume (baking quality) per unit of protein in SD and SH. Whether at low or high protein levels, the SD wheats tend to have an advantage in loaf volume per unit of protein.

We observed the well-known negative relationship between grain yield and protein in both SD and SH wheats. The SD wheats showed an increasing yield advantage at protein levels of about 13% and below, but the SH wheats tended to yield more at protein levels of about 14% and above (data not included).

We have released SD cultivars Shortana (CI 15233), Norana (CI 15927), and Newana (CI 17430) for commercial production in Montana. Each of these SD was as good or better than four SH wheats for nine of the 11 traits measured (Table III), but SH wheats still have better flour yield and flour protein content. One explanation for lower Buhler mill flour yields for SD could be that all samples were milled at fixed mill settings. When SD wheats are milled on the MIAG mill (unpublished data), the settings are made to optimize mill performance. Under these conditions, the SD wheats often perform as well as or better than the SH check.

DISCUSSION

Adequate protein content, milling yield, and baking performance can be incorporated into SD hard red spring wheats. Our data suggest that selection for high grain yield among experimental SD lines may result in decreased protein content but will not adversely affect loaf volume. Traditionally, hard red spring wheat is used by commercial millers to increase protein content and dough strength of bakery flours. If winter wheat protein quantity and bread-baking quality increase as a result of breeding or crop management, the need for high-protein spring wheat could be diminished. The willingness of grain producers to grow lower yielding, high-protein cultivars rather than high yielding, lower protein cultivars depends largely on unit price and protein premiums offered by the trade.

Farinograph dough properties of SD equaled those of SH wheats. The range of protein content found in wheat samples during the study suggests that SD had acceptable dough properties over a wide scope of climatic conditions. Statistically, longer dough mixing requirements appeared in the bake test in only four of the 10 years. Because commercial bakers accept the mixing requirements of currently grown SH wheats, acceptance of carefully selected SD seems assured. Certainly the tolerance to mixing of SD lines, as estimated from farinograph stability times, is as great or greater than that of SH wheats.

Flour yield of SD equaled that of SH wheats in five of the 10 years (Table II). Our data show that our SD experimental lines mill well. They can be identified and released for commercial production to meet the needs of both domestic and foreign flour millers.

Selection for milling and baking quality among SD lines has maintained those traits at the level of commercially grown SH wheats. Improvement in grain yield in SD can result in a slight decrease in protein content. Even though the protein difference between SD and SH wheats averaged 0.5%, loaf volumes were equal.

SD wheats released for commercial production produce excellent baking results and mill as well as many commercial SH wheats.

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