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Winter Durum Wheat: Do We Have All the Answers?

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Introduction

Durum wheat (*Triticum turgidum* L. Var *durum*) comprises approximately 8% of worldwide wheat production. Most of the durum wheat produced in the United States is grown in North Dakota (76%), with Montana, South Dakota, and Minnesota being the other leading states. About four million acres of durum wheat is grown in the U. S. each year. Durum wheat cultivars traditionally grown in the U.S. are spring types, planted in April and May in the upper Midwest, but in the desert Southwest durum is usually planted in December and January. The higher production of fall planted durum has been attributed to a more favorable environment (temperature, moisture) during the growing season.

Durum wheat has the hardest kernel of all wheats and is used to make semolina, which is used to make macaroni, spaghetti, and other pasta products. Durum is the best wheat for pasta products due to its excellent amber color and superior cooking quality. Durum wheat with strong gluten characteristics forms strong, nonsticky doughs ideal for pasta processing and, in general, tends to produce pasta products with superior cooking characteristics (Pitz, 1992).

This publication reports on trials to examine the feasibility of successfully producing durum wheat in Virginia where soft red winter wheat is mainly grown. The specific objectives for the trials included evaluation of yield, quality (including milling characteristics and protein), disease resistance, and winter survival.

Materials and Methods

In 1994, upon a request by Extension agents in the Shenandoah Valley, Frederick County, Clarke County, and Page County, we planted 50 durum wheat cultivars at four locations in Virginia. Among the 50 durum wheat entries, approximately 10 were semi-spring types while the rest were winter types. Among the cultivars used were three Hungarian winter durum wheat cultivars, "Basa," Minaret,"and "Pannondur." The Hungarian cultivars were obtained from Ohio where similar trials were conducted. Basa was describe as a medium early-maturing, moderately-alternative type and Minaret was described as an early-maturing winter type. Pannondur was released in 1985 and was described as an early-maturing winter type with good frost resistance. Additionally, cultivars from Romania, Syria, Ukraine, France, Turkey, Oregon, Colorado, and Arizona were used. (Table 1). In addition to these varieties in 1996, six Russian winter durum wheat lines were included (Table 1).

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Table 1. Line and Origin of winter durum wheat grown in Virginia

Line tested in 1994 and 1996			
Line	**Origin**	**Line**	**Origin**
BZ8W90-27	Phoenix	PANNONDUR	Hungary
BZ8W90-8	Phoenix	MINARET	Hungary
BZ8W91-1	Phoenix	BASA	Hungary
BZ8W91-2	Phoenix	OR3880152	CIMMYT
BZ8W91-4	Phoenix	OR3880158	CIMMYT
BZ8W91-7	Phoenix	OR3880181	Ukraine
BZ8W91-8	Phoenix	OR3910084	Romania
BZ8W92-10	Phoenix	OR3910085	France
BZ8W92-2	Phoenix	OR3910106	Turkey
BZ8W92-3	Phoenix	OR3910214	Romania
BZ8W92-6	Phoenix	OR916121	OSU
BZ8W92-8	Phoenix		
BZ8W92-9	Phoenix		
Lines tested in 1996			
ODESSA #63	Russia		
ODESSA #64	Russia		
ODESSA #65	Russia		
ODESSA #66	Russia		
ODESSA #67	Russia		
ODESSA #69	Russia		

In the spring, plots were visually evaluated for winter survival, disease, lodging, and general characteristics. At planting, depending on soil test recommendations, 600 lb of 5-10-10 fertilizer per acre was applied. An additional 60 to 80 lb N per acre (varied with location) was applied as a split application at growth stage 27 and 35, in March and April, respectively. In July durum was harvested for yield and quality analysis. Standard quality parameters such as moisture, test weight, 1000 kernel weight, and kernel vitreousness were evaluated by the Miller Milling Company. In addition, durum was classified according to USDA standards into grades of 1, 2, 3, 4 or 5, based on its test weight, dockage, and defects. Data were not available in 1995 due to adverse growing conditions. Thus, this report will focus only on data obtained during the 1994 and 1996 growing seasons.

Result and Discussion

Yield

In 1994, the yield advantage of soft red winter wheat was 18, 22, and 23 bu/acre for the Shenandoah, Orange, and Blacksburg locations, respectively (Figure 1). These yield differences were calculated relative to the yield of soft red winter wheat grown at those locations. Lines such as OR3880158 (CIMMYT), OR3910084 (Romania) and OR3910085 (France) yielded the highest among all winter durum wheats planted at the Orange, Blacksburg, and Shenandoah locations, respectively. Overall in 1994, regardless of their varied origin, the OR- lines consistently performed well, followed by lines from Arizona (Western Plant Breeders) at all locations.

During the 1995 growing season, durum data were not available due to adverse growing conditions. At the Orange location a record 11.5 inches of rain between June 22 and July 7 was recorded. Heavy disease pressure earlier in the season coupled with unseasonable rainfall caused preharvest sprouting and head scab that resulted in low yield and poor quality durum.

Winter durum wheat yield was higher for the 1996 growing season at Orange location, and lower at the Blacksburg and Shenandoah locations compared with the 1994 growing season. Thus, in 1996, yield advantage of soft red winter wheat over winter durum wheat was 18, 22, and 24 bu/acre for Orange, Blacksburg, and the Shenandoah locations, respectively. In 1996, in addition to the durum varieties tested the previous years, six Russian lines from Odessa were introduced (Table 1). Yield differences among these lines were evident across locations. Among the Russian lines Odessa #65 yielded highest across locations. However, one line from Arizona (BZ91-8) and OR3910214 (Romania) performed as well as Odessa #65 at the Orange and Shenandoah locations, respectively (Figure 1).

Quality

Test weight:

Test weight is a measure of soundness of wheat. Sound wheat is a wheat that is plump, with fully mature kernels, free of damage that yields in high test weight. There is a positive correlation between test weight and semolina yield. Test weight is influenced by any factor that alters size and shape of kernels such as heat stress, drought, frost damage, or disease. The acceptable test weight for durum wheat is 62 lbs/bu for desert durum and 60 lb/bu for durum produced in North Dakota. Averaged over locations, the 1994 winter durum wheat data indicated that test weight of winter durum wheat cultivars produced in Virginia was at or near the acceptable levels. (Figure 2). Averaged over locations, in 1996, only the test weights of Pannondur (Hungary) and Korall (Colorado) were within the acceptable range. However, when locations were examined separately, 20, 13, and 6 winter durum wheat lines from the Warsaw, Orange, and Blacksburg locations were within the acceptable range. For both years, the Blacksburg location resulted in a lower test weight. The lower test weight found at the Blacksburg location likely was due to adverse weather at harvest time since lower test weight is often associated with mature grain that is exposed to precipitation. Among the durum wheats that consistently met this range across locations were Pannondur and five of the six Russian (Odessa) lines.

1000 Kernel weight

The 1000 kernel weight is associated with semolina yield and test weight. Small kernels will yield less semolina as compared with large kernels since the ratio of endosperm to bran is smaller for small kernels. The acceptable 1000 kernel weight for durum is 35-40 g/1000 kernels. Averaged over the three locations, the 1994 data showed 1000 kernel weight for durum wheat produced in Virginia to be within the acceptable range. Similarly, the 1996 data were acceptable for all the winter durum wheats tested, although the 1000 kernel weights were lower than in the 1994 growing season.

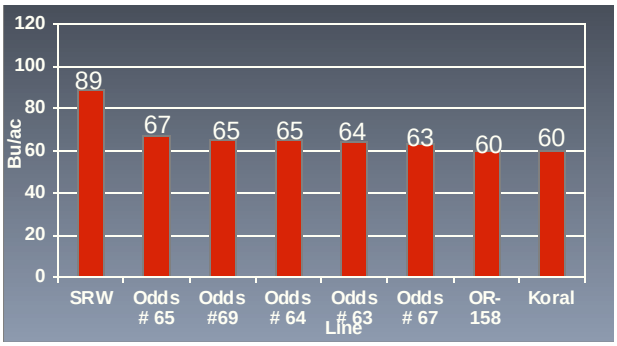
Kernel vitreousness

Kernel hardiness is associated with protein content. Higher protein concentration along with a translucent amber yellow color are referred to as kernel vitreousness. These characteristics are of primary importance in the quality classification of the wheat. There are three official subclasses of durum wheat; each one of these subclasses is determined by the percentage of hard and vitreous kernels of amber color. These subclasses are hard amber durum, amber durum, and durum wheat with high, medium, and low percentage of hard vitreousness, respectively (Durum wheat, 1992). As shown in Table 2, most of the winter durum wheats grown at the Orange location were hard amber durum, while only one and two lines from Blacksburg and Warsaw locations were classed as hard amber durum wheat. None of the durum wheats produced at the Shenandoah location were classed as hard amber (Table 2).

Kernel vitreousness is associated with semolina granulation, color, and protein content. The less vitreous the kernel, the finer the granulation and the lower the color and protein content. Kernels that are

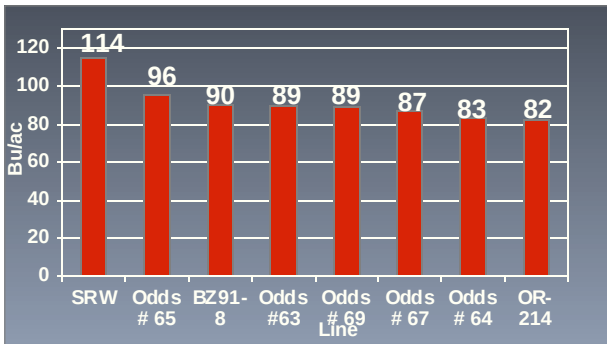
Figure 1. Average grain yields of winter durum wheat and soft red winter wheat cultivars.

Orange, 1994



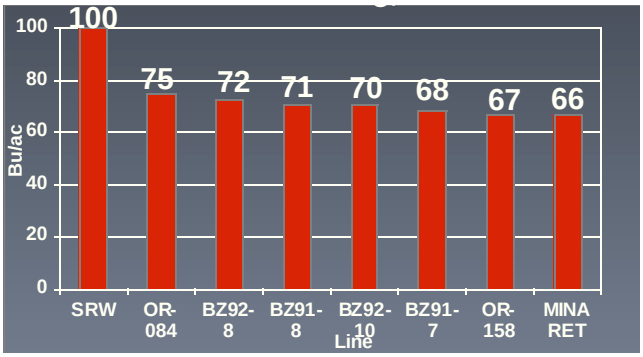
Yield advantage of SRWW vs. Durum = 22

Orange, 1996



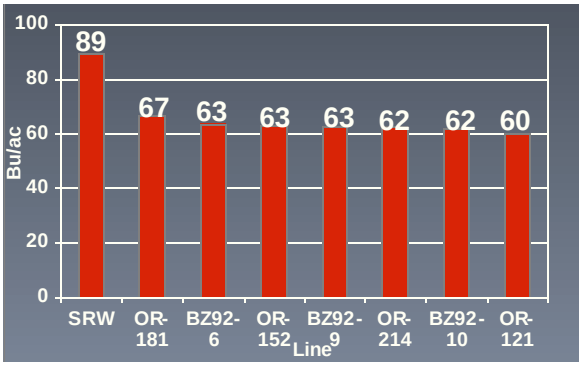
Yield advantage of SRWW vs. Durum = 18

Blacksburg, 1994



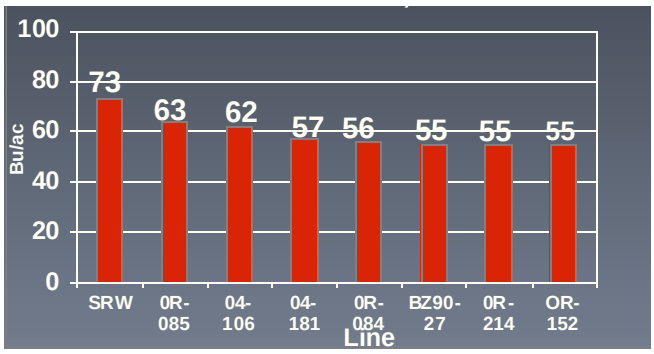
Yield advantage of SRWW vs. Durum = 23

Blacksburg, 1996



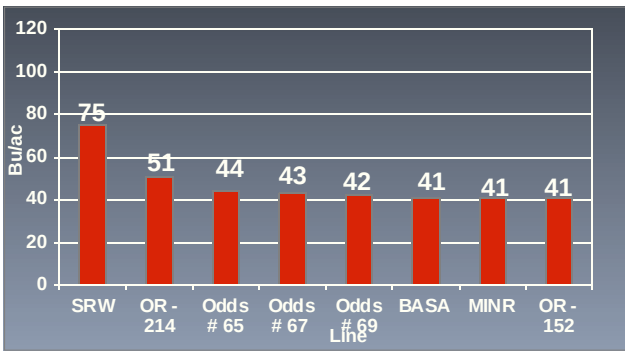
Yield advantage of SRWW vs. Durum = 22

Shenandoah,1994



Yield advantage of SRWW vs. Durum = 18

Shenandoah,1996



Yield advantage of SRWW vs. Durum = 24

Table 2. Classification of durum wheat grown at different locations in Virginia, 1994 and 1996

	Location			
Line	Orange	Blacksburg	Shenandoah	Warsaw
	Durum type			
BZ8W92-6	Hard amber durum	Hard amber durum	Amber durum	Amber durum
BZ8W92-8	Hard amber durum	Durum	———	Durum
BZ8W91-1	Hard amber durum	Durum	Durum	Durum
OR3910214	Hard amber durum	Durum	Amber durum	Durum
OR3910084	Hard amber durum	Amber durum	Durum	Durum
OR3910085	Hard amber durum	Durum	Amber durum	Durum
PANNONDUR	Hard amber durum	Durum	———	Durum
MINARET	Hard amber durum	Durum	Durum	Durum
BASA	Hard amber durum	Durum	Amber durum	Hard amber durum
KORALL	Hard amber durum	Durum	———	Durum
ODESSA #63	Hard amber durum	Durum	Amber durum	Durum
ODESSA #65	Hard amber durum	Durum	Amber durum	Durum
ODESSA #66	Hard amber durum	Amber durum	————	Hard amber durum
ODESSA #69	Hard amber durum	Durum	————	Durum

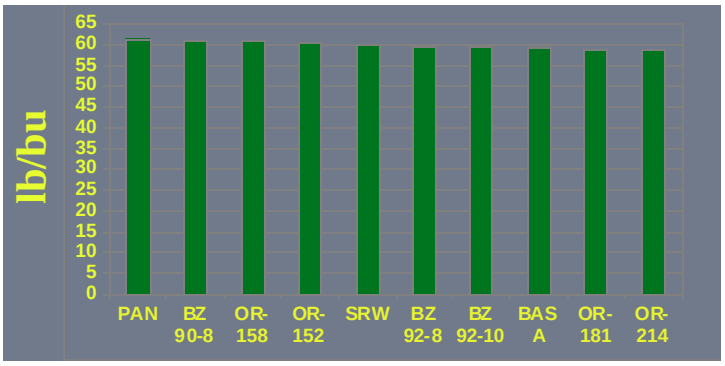
less vitreous will produce more flour thus resulting in less semolina product. Kernels that are vitreous appear glossy and translucent as opposed to starchy. The starchy kernels are also known as "yellowberry." The acceptable minimum value of kernel vitreousness is 91 for desert durums and 86 for North Dakota durums. For the 1994 growing season, averaged over the three locations, Virginia durum failed to meet the standard for kernel vitreousness (Figure 2). However, due to extremely dry growing conditions in 1994, a few cultivars at the Orange locations were above or close to the acceptable range. The lower kernel vitreousness may have been associated with lower protein, since kernel vitreousness is associated with protein content. Averaged over locations, similar results were obtained in 1996. However, looking at locations separately, at the Orange location 22 winter durum wheat lines were within or over the acceptable range (86-97). These durum wheats included five Russian, all the Hungarian, and some of the BZ and OR-lines. One, 3, and 5 durum lines from Blacksburg, Shenandoah, and Warsaw locations had acceptable kernel vitreous levels, respectively.

Protein quantity

The desired protein content of durum wheat ranges from 9% to 18%. Environment plays a greater role in protein content than genotype. Generally, the drier the conditions during the growing season, the higher the protein content. Other environmental factors influencing protein content are soil type, crop rotations (especially those that include legumes), and use of nitrogen fertilization. For quality pasta products, the protein level should be between 12% and 16 % at 14% moisture content. A protein content less than 11% will result in poor quality pasta, while protein levels greater than 16% may be related to lower test weight. Although some varieties were relatively high in protein content, overall, the 1994 growing year results showed a lower protein content. Among the three sites, the durum wheat from the Orange location was higher in protein content (12% compared with 10.5% for the Shenandoah and 10.7% for the Blacksburg locations). The higher protein content of durum produced at the Orange location may have been due to extremely dry conditions during the growing season at this site. In 1996, however, percent protein was within the acceptable level, particularly at the Orange location

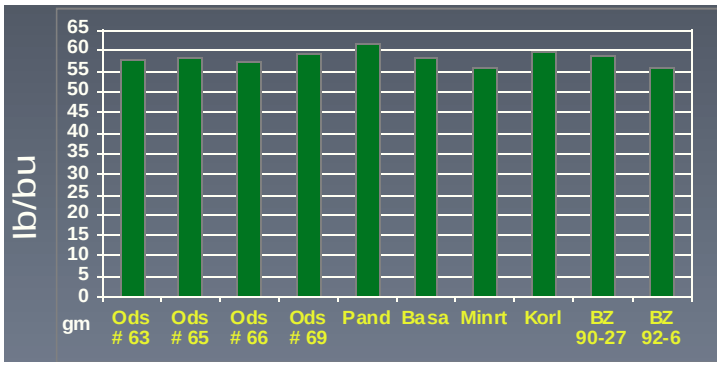
Figure 2. Quality parameters of winter durum wheat averaged over locations

Test weight : 1994



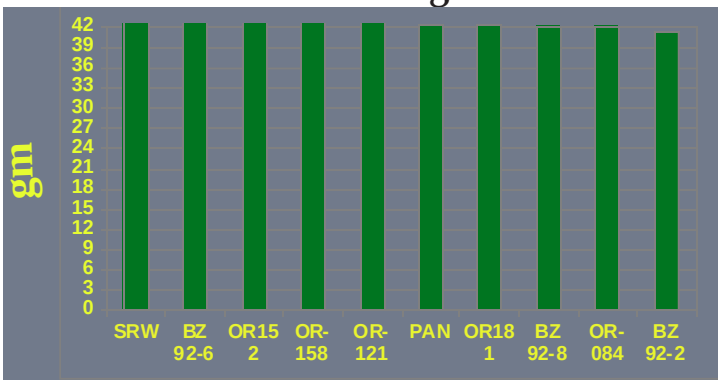
Acceptable range = 60 - 62

Test weight : 1996



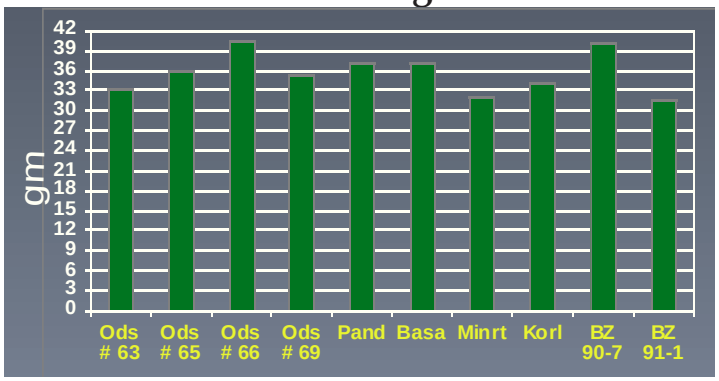
Acceptable range = 60 - 62

1000 Kernel weight : 1994



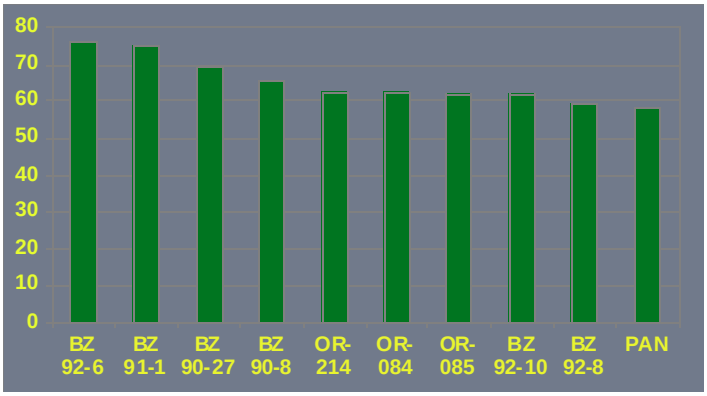
VA Average = 36.0
ND Average = 30+

1000 Kernel weight : 1996



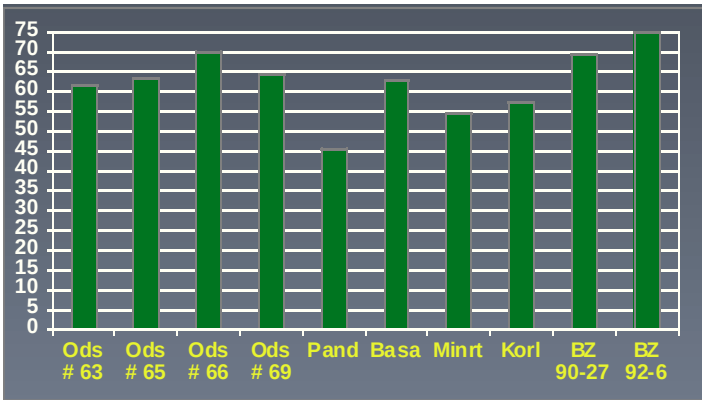
VA Average = 36.0
ND Average = 30+

Kernel vitreousness: 1994



Acceptable range = 75 - 90

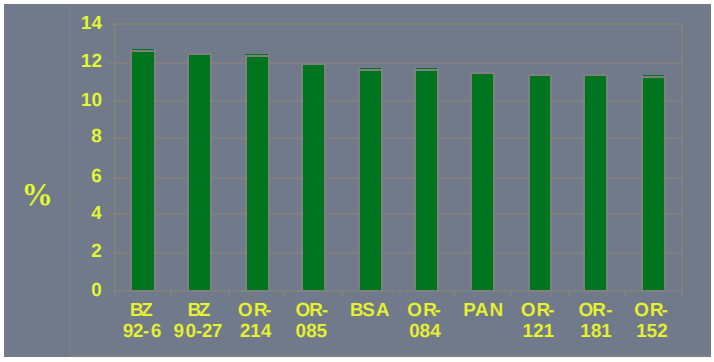
Kernel vitreousness: 1996



Acceptable range = 75 - 90

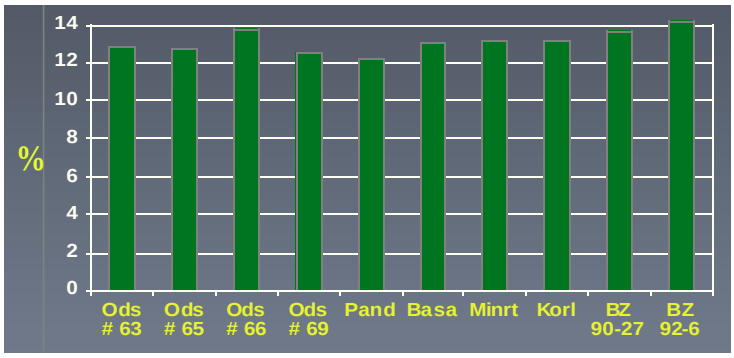
Figure 2.b. Quality parameters of winter durum wheat averaged over locations

Percent protein : 1994



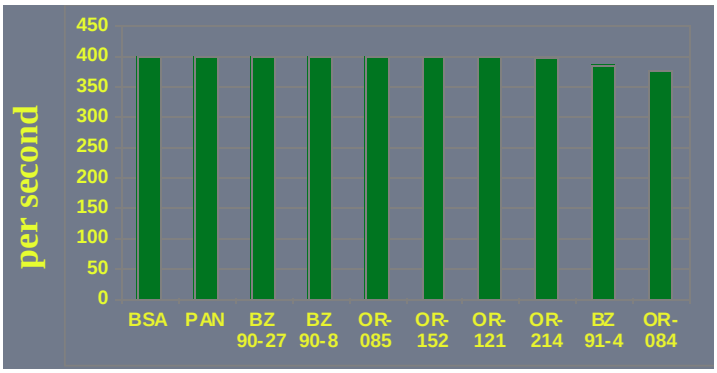
Acceptable range = 11 - 13%

Percent protein : 1996



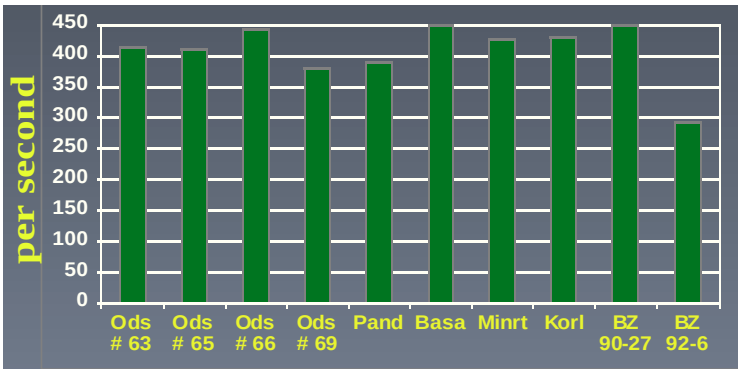
Acceptable range = 11 - 13%

Falling number : 1994



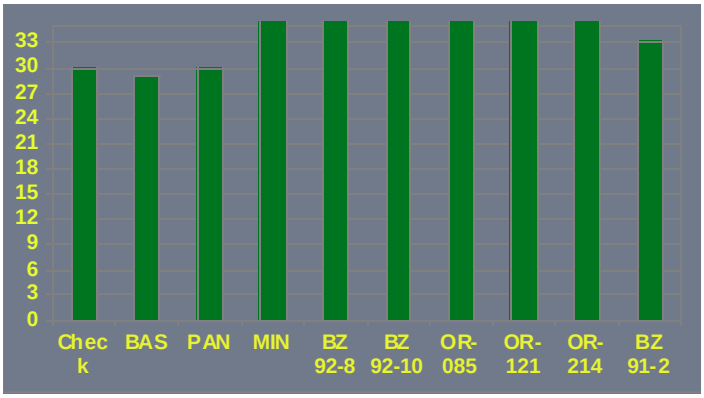
Acceptable range = 250 - 500

Falling number : 1996



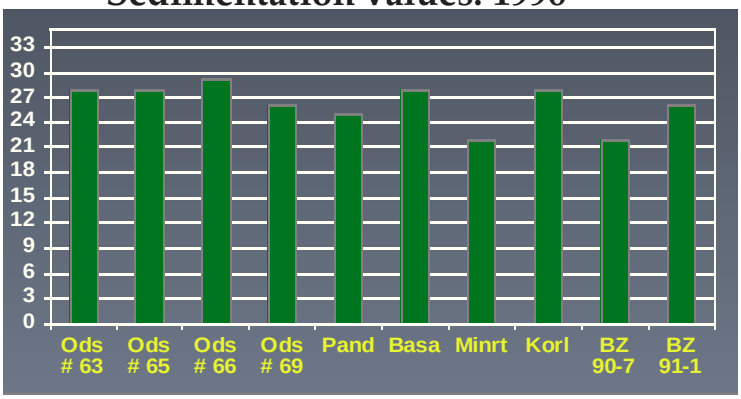
Acceptable range = 250 - 500

Sedimentation values: 1994



VA Average = 25.9
ND = 23.6 (L=20, H=32)

Sedimentation values: 1996



VA Average = 25.9
ND = 23.6 (L=20, H=32)

where up to 15% protein was observed in some winter durum wheat lines. The increase in percent protein for the 1996 growing season was associated with a timely nitrogen fertilization program.

Protein quality

Wheat protein is made up of five different fractions. The difference between these protein fractions is based on solubility. Gliadin, glutenin and insoluble fractions accounts for 80% of the total protein (gluten forming proteins). Gluten is primarily responsible for the end use quality of the wheat; thus, with regard to spaghetti production, both gluten quality and quantity are important (Pitz, 1992). Several approaches have been used to estimate gluten quality. Axford et.al (1978) developed a sedimentation test (SDS) that involved the dispersion of flour in lactic acid and observing the amount of sediment after a fixed period of time. The sediment primarily consisted of swollen gluten and some starch. Sedimentation volumes of 25 to 35 mm indicate moderate gluten-strength varieties, and volumes greater than 35 mm indicate strong-gluten varieties. The SDS values of Virginia grown winter durum wheat were within the acceptable range for both the 1994 and 1996 growing seasons (Figure 2b).

Falling number

Falling number is associated with preharvest sprouting, or pregermination, in the field under prolonged periods of moisture during harvest. Adverse effect of preharvest sprouting in durum is much less apparent. Values between 250-500 are considered acceptable. Virginia durum wheats were within the acceptable range for both 1994 and 1996 growing seasons (Figure 2b).

Conclusions

The first year data (1994) showed that the spring types would not survive some of our winters in the mountain and valley regions. Hence, if durum wheat is to be successful in Virginia we will be focusing on producing a winter as opposed to spring type. Virginia-grown durum wheats yielded lower than soft red winter wheats for all locations. The yield advantage of soft red winter wheat over durum in 1994 was 22, 23, and 18 bu/acre for the Orange, Blacksburg, and the Shenandoah locations, respectively. In 1996, however, the yield difference was 18, 22, and 24 bu/acre for the Orange, Blacksburg, and Shenandoah locations, respectively. The inherent lower yield potential of durum wheat over soft red winter wheat could be compensated by the higher premium price/bushel paid for durum versus soft red winter wheat.

Durum wheats produced in Virginia had acceptable and often higher quality than standard for test weight, 1000 kernel weight, protein quantity, and quality. However, kernel vitreousness and percent protein for most durum wheats tested were lower than the standard. Russian-type winter durum wheats may possibly result in an acceptable vitreous kernel as indicated during the 1996 growing season.

Based on our results from the 1994 and 1996 field trials and on preliminary data from 1997, the potential exists to produce winter durums that would be of an acceptable quality and profitable.

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